CATALOGUE

OF THE

MADREPORARIAN CORALS

IN THE

BRITISH MUSEUM
(NATURAL HISTORY).

VOLUME IV.

THE FAMILY PORITIDÆ.
I.—THE GENUS GONIOPORA.

BY

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LONDON:
PRINTED BY ORDER OF THE TRUSTEES.

SOLD BY
LONGMANS & CO., 39 PATERNOSTER ROW;
B. QUARITCH, 15 PICCADILLY; DULAU & CO., 37 SOHO SQUARE;
KEGAN PAUL & CO., PATERNOSTER HOUSE, CHARING CROSS ROAD;
AND AT THE
BRITISH MUSEUM (NATURAL HISTORY), CROMWELL ROAD, S.W.

1903.

LONDON :
PRINTED BY WILLIAM CLOWES AND SONS, LIMITED
GREAT WINDMILL STREET, W., AND DUKE STREET, STAMFORD STREET, S.E.

PREFACE.

NEARLY six years have elapsed since the publication of the third volume of this Catalogue. The causes of the delay in the appearance of this fourth volume are explained by the author in his Introduction.

This volume deals with *Goniopora*, which was always thought to be a small genus of purely recent reef corals. Mr. Bernard's study of the rich collection of fossils contained in the Geological Department, a study undertaken at my request, has revealed the fact that an important Tertiary coral (*Litharæa*) is generically identical with *Goniopora*; the genus can now be traced back to early Cretaceous times, and seems to have had a period of maximum development in the early Tertiary beds of South Europe. The fossils, moreover, threw much new light, which could not otherwise have been obtained, upon the morphology of the genus.

The variability of the corals has, in previous volumes, been a good deal obscured by the establishment of a number of so-called species; the author has thought it right to cease establishing genetic groups without the necessary data for so doing. He regards his task as that of presenting the facts and what may legitimately be deduced from them in the way that will be most useful to future workers, and to the officials of other Museums. Experience alone can show whether the method he has adopted in order to attain this end, however faultless its logic may be, can be employed with advantage in dealing with any other group besides the corals, or even whether it is the best way of presenting the corals, having regard solely to the facts. The attempt is, however, a sign of the times, for it is clear that, whether the older school of systematists like it or not, the question of method is an increasingly serious one, and Mr. Bernard's attempt should stimulate inquiry outside the beaten paths.

The first thing that will strike the reader is the change in the formula, the author having completely abandoned the old methods of naming in favour of geographical symbols. At my request he has added the concluding remarks on p. 190, not to make clearer the explanation of his system given on pp. 3 and 31 of the Introduction, but to deal especially with this purely formal innovation, which some, who have not gone very deeply into the subject, may think needlessly drastic. It may be remembered that this is not the first time that the inadequacy of the ordinary methods followed by naturalists has been pointed out in a preface to a Museum Catalogue.*

Some sixty-eight records of *Gonioporæ*, hidden under various generic names, with a bewildering repetition of some five or six specific names, were found in previous writings. Wherever possible they have been rediagnosed. These, with the new forms described for the first time, bring up the total number of known forms to about 150, 80 per cent. of which are figured. With this greatly extended series for comparison, it has been possible to make out several new types of calicle structure and of growth-form, and to obtain some conception of the form and structure of the primitive Gonioporan colony. The conclusions arrived at have, in the main, confirmed the position assigned to the genus in the classical works of Milne-Edwards and Haime.

The special thanks of the Trustees of the British Museum are due to the Directors and Assistants of other Museums for their courtesy either in lending specimens, or in other ways assisting Mr. Bernard in the study of specimens under their charge: to Prof. Ed. Perrier, Director of the Museum of Natural History, in Paris; to Prof. Portis, Director of the Geological Museum of the University of Rome; to Dr. Horst of the Museum of Natural History in Leyden; to Dr. T. Wayland Vaughan of the United States Geological Survey; to Dr. Harmer, F.R.S., and to Mr. J. Stanley Gardiner of Cambridge; also to Dr. Charles Gravier of Paris, Dr. Angelis of Rome, and Mr. S. Pace, now of the Plymouth Marine Biological Laboratory.

Of recent additions to the Museum, special mention should be made of the number of new *Gonioporæ* contained in Mr. W. Saville-Kent's collection from the

* Catalogue of Fishes, vol. vi. (1866).

Great Barrier Reef. Several quite unexpected forms occur among those found by Mr. Bassett-Smith, R.N., especially valuable because of the detailed information which accompanies them. The same applies also to the specimens presented to the Museum by Mr. J. Stanley Gardiner, the bulk of whose collection belongs to the Cambridge University Museum, and has been kindly lent for the purposes of this work.

This volume has had the advantage of having been carefully edited throughout by Mr. F. Jeffrey Bell, the member of the permanent staff who has charge of the collection of recent corals. Mr. Bell has rendered Mr. Bernard invaluable assistance during the whole course of his studies for this volume, having shown the keenest interest in every detail of the work.

The parts dealing with the fossil forms have been carefully revised by Mr. R. Bullen Newton who, in the Geological Department, has official charge of the fossil corals. He has spared no pains in rectifying the horizons according to the latest available sources of information.

An improvement has been made upon the methods of illustration adopted in previous volumes of this Catalogue. Formerly the specimens were photographed, and magnified lithographic drawings were made of the finer structural details. In this volume, magnified photographs of these latter were taken by a photographic expert, Mr. T. Murray, sent by Messrs. Morgan and Kidd, who, as in the case of the former volumes, prepared the collotype reproductions of the same; the growth-forms are given in lithographic drawings executed by the skilful pencil of Mr. A. T. Hollick. The motive of the change was to apportion to each method of illustration that part of the work to which it is best adapted. It is obvious that, excellent as Mr. Percy Highley's drawings for Vol. III. are, the bewildering details of the reticular skeletons of *Gonioporæ* can only be truly and expeditiously reproduced by photography.

E. RAY LANKESTER.

10*th March*, 1903.

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CATALOGUE

OF

MADREPORARIA.

VOLUME IV.

THE MADREPORARIAN FAMILY PORITIDÆ (GONIOPORA AND PORITES).

INTRODUCTORY REMARKS.

THIS volume is the first instalment of the result of nearly five years of work on the Madreporarian family the Poritidæ, which of all is probably the most difficult to understand. In it, what is called the porosity of the skeleton reaches a climax, with the result that all the characteristic morphological features of the Stony Corals lose their distinctness. Instead of a corallum built up of many clearly cut calicles with conspicuous septal lamellæ, we have to deal with skeletal networks from which, in extreme cases, all the typical radial symmetry may have disappeared.

Before any progress could be made with such a group, these complicated morphological details had to be worked out. This was necessary in order to form a clear conception of the connections between this type of Madreporarian skeleton and other better known types—better known, that is, because more easily understood. No trustworthy results as to the essential characters of any form of life can be obtained from examination of a few stray specimens alone. The range of variation of all the available specimens, recent and fossil,* requires to be studied, and then what is essential and what is not essential become slowly and gradually

* But for the light thrown by fossil forms, many of the most important morphological features of this genus, on which the systematic description must be based, e.g. the septal formula, would probably not have been discovered. It is gratifying to be able to record this, because this is the first volume of the Madreporarian Catalogue in which, by special instructions of the Director, Professor E. Ray Lankester, the genus has been treated as a whole, irrespective of the fact that many of its representatives are now only known as fossils.

differentiated. In this case, it was found that owing to the morphological obscurity of the family, over twenty-seven genera, recent and fossil, had been from time to time incorporated into it. Many of these gave a great deal of trouble. An illustration will make this clear, and at the same time exemplify the method by which the difficulties were overcome.

The genus *Alveopora* has a fragile, porous skeleton, which gives it a superficial claim to be a Poritid. This claim, founded originally on the famous trabecular theory of coral morphology, which formed the basis of the great work of Milne-Edwards and Haime, becomes strong when it is found that specimens of the chief Poritid genus *Goniopora* simulate the skeleton of *Alveopora* so closely * that it was possible for anyone to maintain that the two genera passed into one another. Those who doubted the relationship had apparently no more ground for doubting than those who affirmed it had for affirming it. It was a mere question of similarity between stray specimens on one side, and dissimilarity of stray specimens on the other. This question as to whether the Poritidæ could or could not include the genus *Alveopora* had, then, to be decided one way or the other before any clear conception of the essential morphology of the family could possibly be arrived at. Preliminary draft catalogues of all the specimens in the National Collection, first of the genus *Goniopora*, then of *Alveopora*, and lastly of *Porites*, had to be prepared. Only in the course of this work did the distinguishing morphological details stand out clearly enough to enable this volume to be written.

In passing, it may be stated that the analysis of the genus *Alveopora* resulted in the confirmation of the view which regards it as a survival of the Palæozoic Favositidæ, a family which, except for the genus *Alveopora*, has long become extinct.† The place, then, of this genus in this catalogue must be in the series dealing with the most primitive forms and nowhere near the Poritidæ, which stand at the very head of the tribe as the most recent and specialised.

The results of the work on *Goniopora* and *Porites* will be found in this and in the next volume (Vols. IV. and V.). I may add that the final separation of *Alveopora* from the Poritidæ was by no means the only question which had to be solved. For instance, *Goniopora* and *Porites* were clearly both Poritids. But the relationship between them has only become clear to me during the last year, after I had reluctantly begun to prepare these pages for press, having decided to leave this relationship an unsolved problem. For the solution, see Sec. IV. p. 27.

Then again, the difficulty of unravelling the morphology of the genus itself may be gathered from the fact that an apparently perfectly simple question has puzzled every student of the genus in turn (see Historical Sketch). The problem is: which are the older calicles, those at the top or those at the side of a massive stock? The solution here arrived at (see Sec. III.) was most unexpected, and there is no wonder that the problem has been a standing difficulty. It can hardly fail to have a fascination for every student of coral morphology.

In addition to these complex morphological problems, the solution of which has so delayed the appearance of this volume, a difficulty of a totally different character arose and had to be

* Cf. e.g. *G. Great Barrier Reef 10*, p. 56. † See Journ. Linn. Soc., xxvi. 1898, p. 495.

dealt with. Apparently a mere question of technical method, it assumed an importance which in itself it in no way deserves.

In the Preface to the British Museum Catalogue of Fishes, Vol. VI., Dr. Günther observed that, owing to the extraordinary variability of the Salmonidæ, the ordinary method of distinguishing and determining their species was utterly inadequate. This is still more true in the case of the Stony Corals. Indeed, I have no hesitation in asserting that in the present state of our knowledge coral species are indeterminable. Nevertheless, in previous volumes the specimens showing striking differences of structure were named and called "species." This was done solely in accordance with long established practice. For while, in the absence of the data necessary for their arrangement into genetic groups, there was and could be no pretence that specimens arranged under the different headings were real "species" in the strict sense of closely related groups, the names served a useful purpose as mnemonics relating to the known structural variations presented by the genus. Experience showed me, however, that this usefulness varies in inverse proportion with the size of the group, that is, with the magnitude of the burden it has to undertake. The long lists of names which were steadily growing as I proceeded to designate every apparently different form of *Porites* in the old way, got completely out of hand. This fact, apart from the fundamental confusion of idea involved in calling them "species,"* convinced me that if the systematic work to which I had devoted so much time were to have any scientific value at all, some new method of presentment must be adopted. The time ought to have passed when the value of a systematic treatise is to be reckoned by the number of new "species" established. It must, in the future, be sought in the accessibility of the details relating to new observations, in the accuracy of those observations, and in the ability with which they are correlated with already ascertained facts.

The method adopted will be described in detail in Sec. VII., and the first attempt at its practical application will be found in the following pages of this volume. Its appearance may be strange and forbidding for a time because it has not resulted in a "classification" in the ordinary sense, which means the arrangement of the collection into so many representatives of ideal species set up on the slippery evidence of the, mostly, isolated, and often fragmentary specimens themselves. But if there is no conventional attempt at a genetic classification, because the facts do not justify any such attempt, there is, instead, a *catalogue of the known forms* presented in such a way as to render the available facts readily accessible to students of the genus. The data are so arranged that they may be supplemented at any time without the necessity for any of the usual subversive re-shuffling and re-naming which at present makes systematic work in a group like the corals a labour of Sisyphus. In time doubtless the requisite knowledge will be available for the analysis which will reveal to us the species. For, in the nature of things, the species can only be discovered by the same analytical processes which enable us to separate out the genera.†

* Cf. on this subject an article by Prof. Döderlein, Zeitsch. f. Morphologie und Anthropologie, iv. (1902) p. 394.

† See further 'On the Unit of Classification for Systematic Biology, Proc. Cambridge Philosophical Society, xi. (1902) p. 268.

The Family PORITIDÆ.

HISTORICAL.

The family Poritidæ was founded by Dana in 1848 * to contain two genera, *Porites* and *Goniopora*. These were placed in the tribe Madreporacea, characterised by having polyps with 12–24 tentacles in a single ring, and with lateral gemmation. The Madreporacea were divided into three families,—Madreporidæ,† Favositidæ,‡ and Poritidæ.

In this juxtaposition of the Poritidæ with the Madreporidæ Dana was following the lead of Ehrenberg, on whose classification he greatly improved by recognising the structural differences between the two. In the latter the calicles are deep and can be traced through the corallum, while the polyps rise but a little way above their skeletal cups. In the Poritidæ the calicles are shallow, the skeleton fills up with reticulum, so that the calicles are hardly traceable through the corallum, and the polyps rise high above the surface.

The great divisions of Stony Corals, the Madreporaria aporosa and M. perforata, established by Milne-Edwards and Haime, marked a great advance; for the separation of the Eupsammiidæ, Madreporidæ, and Poritidæ from the rest of the Stony Corals has been fully justified. These distinguished authors were not, however, guided by the knowledge we now possess as to the morphology of the skeleton; this is apparent the moment we come to their detailed treatment of the families. Though at once § accepting the family Poritidæ of Dana and improving on Dana's arrangement so far as to remove the Favositidæ (with the exception of *Alveopora*) from any association with it, or with the Madreporidæ, their removal of *Montipora* from the Madreporidæ, and their placing it among the Poritidæ was a backward step. To this they were led by their well-known theory of the origin of the coral skeleton out of calcareous nodules. These they thought were joined end to end into trabecular lattice-works, the radial portions of which in the higher forms became lamellate septa. According to this theory, therefore, all corals in which the skeleton was wholly reticular, showed primitive conditions, and were classed as Poritidæ. Hence, in the description given of this family, we read, "Appareil septal jamais complètement lamellaire, et formé seulement par des séries de trabécules qui constituent par leur réunion une sorte de treillage. . . . ."

This theory, however, is unsupported by facts. The most perfect trabecular septa, accord-

* The United States Exploring Expedition: Zoophytes, p. 549.

† See Vols. I., II., III. of this Catalogue. The family Madreporidæ is discussed in the Introduction to Vols. II. and III.

‡ This family "Favositidæ" was quite artificial, and further the genera *Favosites* and *Alveopora* have no connection whatever with *Porites*.

§ C.R., xxix. (1849) p. 258, and Ann. Sci. Nat. (3°) xvi. (1851) p. 21.

ing to the definition, are those figured by Pratz for *Cyclolites* and *Thamnastræa*,* and these are certainly not primitive corals, nor do they belong to the Poritidæ, as can be shown by an analysis of their structure.† Led astray by this theory, Milne-Edwards and Haime ignored Dana's important diagnosis of the essential difference between Poritids and Madreporids.

In their hands, therefore, the family was artificially increased, and appeared in 1860 in 'Les Coralliaires,' vol. iii., as follows :—

PORITIDÆ.‡

PORITINÆ.	MONTIPORINÆ.
Porites, Rhodaræa, Goniopora,	*Montipora, Psammocora.*
Litharæa (Tert.), *Protaræa* (Silur.), *Alveopora* (Rec.),	
Microsolena (Jur.), *Mæandraræa* (Ool.), *Coscinaræa* (Rec.),	
Pleurodictyum ? (Dev.), *Dictyophyllia ?* (Cret.).	

Of these only *Porites, Rhodaræa, Goniopora,* and *Litharæa* are true Poritids, and the last three are here united into one genus *Goniopora,* which with the genus *Porites* constitute the family Poritidæ.

In his ' Introduct. à l'étude des polypiers fossiles' (1858–61) Fromentel proposed a modification of the system of Edwards and Haime, dividing each division into Monastrææ, Dyastrææ, Synastrææ, and Polyastrææ. Among the Perforata polyast. occur the Poritinæ M.-E. & H., with *Alveopora* and *Goniopora* left out and *Holaræa* added.

In 1865, Professor Verrill § sketched a new classification of the order Madreporaria, the fourth suborder being Dana's Madreporacea. We here find the relationship between Poritidæ and Madreporidæ reaffirmed, and in 1866 ‖ the families were arranged in the following order: Madreporidæ, Poritidæ, Eupsammidæ.

In arranging the family itself he ¶ endeavoured to reconcile Dana with Milne-Edwards and Haime. He agreed with the latter that *Alveopora* was a Poritid, but thought with Dana—and in this they were supported by Saville-Kent **—that it was at the same time a Favositid. He therefore proposed to divide the family into three sub-families, Poritinæ, Alveoporinæ, and Favositinæ. This arrangement is quite artificial.

Professor Verrill increased the number of genera contained in the family by the addition of *Synaræa,*†† but rejected the genus *Neoporites* proposed by Duchassaing and Michelotti in 1864 in their description of corals from the Antilles.

In 1866, ‡‡ Reuss described fossil Poritids (Eocene) from Java and gave an account of a new

* Palæontographica, xxix. (1882) pl. xiv. figs. 2 and 10.

† For a further criticism of this theory, see Journ. Linn. Soc., xxvii. p. 137.

‡ For those of the following genera which, in this Catalogue, are not accepted as belonging to the Poritidæ see the list, p. 9.

§ Proc. Essex Institute. iv. p. 145.

‖ Trans. Conn. Acad. i. (1866) p. 503.

¶ Amer. Journ. Sci., iii. (1872) p. 194.

** Ann. Mag. Nat. Hist., vi. (1870) p. 386.

†† This genus cannot really be separated from *Porites*, as will be shown in Vol. V. dealing with that genus.

‡‡ Reise der Öst. Fregate 'Novara,' Geol. Theil, Band ii.

genus *Dyctyaræa* which he placed among the Poritids. It is here discussed on p. 30. In many other treatises he described new species of *Litharæa* (*Goniopora*) and *Porites*, but could not clearly distinguish the one genus from the other, for most of his *Porites* are true *Gonioporæ*.

In 1875, Milaschewitch in his continuation of Dr. Becker's account of the Corals of the Natheim Strata,* adopted Milne-Edwards and Haime's system, but increased the number of genera of their Poritinæ to 22. These were said to fall into three groups.

In the first, the pores in the septa are in straight rows—Thamnastræaceæ.

In the second, pores in no definite order—Gonioporaceæ.

In the third, the septa are only spines—Alveoporaceæ.

This method of grouping on mere texture of the septa alone, without regard to the morphology of the calicle as a whole, is, as we shall see, quite untenable.

In 1879, two posthumous papers from the pen of Brüggemann appeared. Though both are purely systematic and the principles of the classification are not analysed, yet we gather from the order adopted, that he had not arrived at any definite opinion as to the position of the Poritidæ. In one † we have three families, Madreporidæ, Poritidæ, and Montiporidæ, and in the other ‡ (*Madrepora*), *Montipora*, *Turbinaria*, *Porites*, *Synaræa*, and *Psammocora* ranged together as genera under the Madreporidæ.

In his MS. catalogue of the British Museum corals, he, like Prof. Verrill, rejected the genus *Ncoporites* D. and M.

In the same year, Dr. Klunzinger § placed the Poritidæ between the Madreporidæ and Turbinaridæ, thus unfortunately separating *Turbinaria* and *Astræopora* from the Madreporidæ (see Introduction, Vol. II.). In Dr. Klunzinger's description of the family it is stated that the calicles are joined by walls, not by cœnenchyma (except in *Synaræa*). For a criticism of this statement see below, p. 19.

Dr. Klunzinger very rightly abolished the Poritid sub-family Montiporinæ M.-E. and H. (for the Madreporid sub-family Montiporinæ see Vol. III. of this Catalogue), and removed *Coscinaræa*. On the other hand, he retained *Alveopora* and *Synaræa* (which he placed at the opposite extreme of the family from *Porites*). He further revived a genus *Stylaræa* which had been established but suppressed again in the same year by Milne-Edwards and Haime; this will be discussed in Vol. V.

In 1878 ‖ Dr. Studer adopted the following classification. The family Madreporidæ was divided into three sub-families, Madreporinæ, Poritinæ (the genera mentioned being *Porites*, *Synaræa*, and *Goniopora*) and Montiporinæ. But in 1880,¶ the same author found the following two families sufficient, the Madreporidæ—which now rightly included *Montipora*—and the Poritidæ with *Rhodaræa* and *Alveopora* added to the list of the genera.

In 1882, Pratz,** following Milaschewitch, made a still more thorough investigation of the

* Palæontographica, xxi. p. 217.
† Corals of Rodriguez, Phil. Trans., clxviii. p. 569.
‡ Journ. d. Mus. Godefroy, v. p. 201.
§ Korallenthiere d. rothen Meeres, ii. p. 39.
‖ MB Akad. Berlin, p. 524.
¶ Mitth. Naturf. Ges. Bern, p. 22.
** Palæontographica, xxix. p. 83.

structure of the septa in *Cyclolites, Thamnastræa,* and a few other "Poritids" of Milaschewitch (see last page). They are figured as apparently ideally trabecular in the sense originally meant by Milne-Edwards and Haime.

Pratz did not, however, follow Milaschewitch in regarding all corals with such septa as Poritidæ. He would rather deduce the true Poritids from the Pseudastræinæ (= Thamnastræinæ and Cyclolitinæ) which he regarded as Fungids. The nearest ally according to this scheme is the genus *Thamnaræa* Etall.* ; which, however, seems to me to be too insufficiently diagnosed to be assigned any definite place in the coral system. With reference to Pratz's work, we must again remark that the Stony Corals cannot be classified on one structure alone, even though that structure is the septum.

In 1884, Martin Duncan † published his revision of the Madreporarian system of Milne-Edwards and Haime. The Poritidæ were divided into two alliances, Poritinoida and Montiporoida. The list includes all Milne-Edwards' recent genera (except *Coscinaræa*) together with *Synaræa* Verrill, which is placed next to *Porites,* and a new genus, *Napopora* Quelch. He did not follow Klunzinger in reviving *Stylaræa. Montipora* (with the allied *Anacropora* Quelch) was thus replaced among the Poritidæ in face of the opinion of so many of the authors quoted.

In describing the family he follows Dr. Klunzinger in stating that the corallites are joined "by their trabeculate walls without intervening cœnenchyma" (see below, p. 19).

In 1886, Mr. Quelch, in his report on the 'Challenger Reef Corals,' as I think correctly placed the Poritidæ immediately after the Madreporidæ. The same advance is not found in the more detailed treatment of the family; for *Alveopora* was retained, and *Synaræa* separated from *Porites* by a new transitional genus *Napopora* (not here accepted, see list, page 9). A second new Poritid genus *Tichopora* was established and placed after *Goniopora* and *Rhodaræa.* This has also been rendered unnecessary as the range of specific variation absorbs it (see p. 16). No description of the family was given by Mr. Quelch.

In the year 1887, Dr. Ortmann ‡ somewhat modified Pratz's conclusion. Dr. Ortmann's Poritidæ (= Madreporaria Perforata M.-E. & H.), include the sub-families Turbinarinæ, Montiporinæ, Poritinæ, Madreporinæ, and Eupsamminæ. Of the special origin and relationships of the Poritinæ he says little, but his larger Poritidæ he would deduce through *Actinaræa* and *Microsolena* from the family Thamnastræidæ, to which he gave far greater importance than had Pratz, subordinating to it not only the Poritidæ but also the Fungiidæ. He expresses the relationships of the great groups of the Hexacoralla in an interesting tree (l. c., p. 204).

In 1888,§ the same writer again uses the word Poritidæ in the wider sense above noticed, but in the purely systematic parts of his paper he adopted the term Poritidæ in its usually limited sense. He may have intended the word "Poritinæ." The included genera are the same as those of Dr. Klunzinger, except that *Synaræa* is brought next to *Porites.*

In the following year, 1889, the same writer ‖ elaborated a new division of the Stony Corals

* Lethæa Bruntrutana, 1864, p. 412.
† Journ. Linn. Soc., xviii.
‡ Neues Jahrb. Mineralogie, 1887, pt. ii. p. 183.
§ Zool. Jahrb., iii. (Syst.) p. 143.
‖ Zool. Jahrb., iv. (Syst.) p. 493.

according to the way the septa were united to form thecæ. (1) Athecalia, when the union was discontinuous and brought about by scattered synapticulæ resulting in a kind of porous theca; (2) Euthecalia, in which the septa were united by a continuous outer wall from the inner surfaces of which they projected; and (3) Pseudothecalia, in which the theca was continuous but not a distinct structure, being due to fused lateral thickenings of the septa. This new principle of classification necessitated a recasting of the scheme sketched in 1887. This affected the Poritidæ, which had now to be classified as of the order Athecalia, sub-order Madreporaceæ, of equal value with Thamnastræaceæ and Fungiaceæ. The Poritidæ belong to the Madreporaceæ and contain the genera *Psammocora, Synaræa, Porites.* The genus *Goniopora* is not mentioned. A new genealogical tree is given which again deduces *Porites* with *Astræopora* from *Actinaræa* and *Microsolena.* The relationship of the genus to *Madrepora* is close but left uncertain. With regard to this whole system, we may again remark that the wall taken alone is just as unable to supply us with a classification as are the septa relied upon by Milaschewitch and Pratz (see above).

In 1896, Miss Ogilvie* again took up the *Poutrelle* (trabecula) of Milne-Edwards and Haime, and extending the work of Pratz sought to make the fine structure of the septa the fundamental basis of classification. On these lines, however, she found it impossible to decide whether the Poritidæ were or were not related to the Madreporidæ, or were an independent development. On page 340 Miss Ogilvie suggested dividing the Poritidæ into Poritinæ and Spongiomorphinæ Frech. Among the ancestors of the Poritidæ we find suggested the following genera: *Litharæa* and *Dictyaræa* (Tert.), *Astræomorpha* and *Heptastylis* (Trias.), *Protaræa, Stylaræa, Coccoseris,* and *Thecia* (Pal.). (See list on the opposite page.)

In 1899,† the present writer introduced a new character for the classification of the Stony Corals, viz. the primitive epithecal cup. The close relationship of the Poritidæ and Madreporidæ with the Eupsammiidæ (Perforata M.-E. & H.) was entirely confirmed, for in all of them the epithecal cup is early flattened out, and the subsequent skeleton is built up solely of the septa with their junctions. The family Poritidæ was limited to two genera, *Porites* and *Goniopora,* and was derived from Madreporids which budded very early, i.e. while the skeleton was still an immature basal structure. This view is in the main adhered to in this volume, but the proposed relationship of the genus *Goniopora* to *Porites* has been reversed, owing to the discovery of the septal formula of *Goniopora* and the fact that it passes into the septal formula of *Porites* by a process of reduction.

The following is a list of genera which have been claimed as Poritidæ, or suggested as possible ancestral forms, and here either excluded altogether, or merged with one of the two genera *Goniopora* or *Porites.*

1. *Actinaræa* D'Orb. (= *Agaricia granulata*, Goldfuss, Petref., pl. xxxviii. fig. 4), suppressed by Duncan as = *Microsolena*, in his 'Revision of the Coral System of Milne-Edwards and Haime,' Journ. Linn. Soc., xviii. (1884) p. 168.

2. *Alveopora* Quoy and Gaimard, Voy. de l'Astrolabe, iv. (1833) p. 238. A Favositid, *vide* Journ. Linn. Soc., xxvi. p. 495.

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* Phil. Trans., clxxxvii. p. 326. † Journ. Linn. Soc., xxvii. pp. 128, 487.

3. *Astræomorpha* Reuss (Wiener Denksch., vii. (1854) p. 127). See Duncan's Revision, p. 135.
4. *Coccoseris* Eichwald (Lethæa Rossica, i. pt. 1 (1860) p. 442). Placed by Lindström among the Heliolithidæ, Kong. Svenska Vetens.-Akad. Handlingar, xxxii. (1899–1900) p. 189.
5. *Cœnostroma* Winchell (Proc. American Assoc., 1866). On this genus also see Lindström, ix. pt. 2 (1870) p. 6 of the same publication.
6. *Coscinaræa* M.-E. & H. (C.R., xxvii. (1848) p. 496). Placed by Dr. Klunzinger among the Fungidæ, Cor. des rothen Meeres, iii. (1879) p. 78; see also Duncan's Revision, cited above.
7. *Cosmoporites* Duch. and Mich. (Les Cor. des Antilles, supp. (1864) p. 99). Not sufficiently distinguished from *Porites*.
8. *Dichoræa* Woods (Linn. Soc. New S. Wales, iii. (1879) p. 96, pl. x. fig. 4). This minute coral appears to me to be allied to the Favositidæ.
9. *Dictyaræa* Reuss (Novara Expedition, vol. ii. (1866) p. 175). On this genus see the remarks made on p. 30.
10. *Dictyophyllia* de Blainville (Dict. Sci. Nat., lx. (1820) p. 325) = *Mœandrina reticulata* Goldfuss, pl. xxi. fig. 5; cf. also the figure of *Cleistopora* in Nicholson's 'Manual of Palæontology,' i. (1889) p. 310. See also Duncan's Revision, p. 131.
11. *Dimorpharæa* Fromentel ('Introduction à l'étude des polypiers fossiles,' 1861, p. 254.) This, according to Duncan, is a Microsolenid (see his Revision, p. 170).
12. *Heptastylis* Frech. (Palæontographica, xxxvii. p. 18). The resemblance of this to the Poritidæ is purely superficial.
13. *Holaræa* M.-E. & H. (C.R., xxix. 1849, p. 259). Subsequently merged with *Axopora* in 'Les Coralliaires,' iii. (1860).
14. *Mœandraræa* Etallon (Lethæa Bruntrutana, 407, pl. 57, pp. 11 and 12). There is not sufficient evidence to connect this with the Poritidæ.
15. *Microsolena* Lamouroux (Exp. Method (1821) p. 65). The long septa running from calicle to calicle in curved lines is not a character of the Poritidæ.
16. *Napopora* Quelch (Ann. Mag. Nat. Hist., xiii. (1884) p. 296). Merged with *Porites* in Vol. V. of this Catalogue.
17. *Neoporites* Duch. and Mich. (Cor. des Antilles, supp. (1864) p. 97. Merged with *Porites*.
18. *Palæoporites* Kiär. (Palæontographica, xlvi.). The name of this new genus seems to suggest a phylogenetic connection with the recent Poritidæ; but if it is a Heliolithid it could not be related to any member of the true Perforata.
19. *Pleurodictyum* Goldf. (Petref. Germ., i. (1829) p. 113) is a Favositid.
20. *Protaræa* M.-E. & H. (Pol. foss. Terr. Pal. (1851) p. 208). See Lindström's Heliolithidæ (cited above).
21. *Psammocora* Dana (Zooph. (1848) p. 344). See Duncan's Revision; also Dr. Klunzinger's work above quoted.
22. *Rhodaræa* M.-E. & H. (C.R., xxix. (1849) p. 259). Merged with *Goniopora* (see this volume p. 15).
23. *Somphophora* Lindström (Richthofen's China, iv. (1883) p. 51) is a Favositid.
24. *Stylaræa* Seebach (Zeitsch. Deutsch. Geol. Ges., xviii. (1866) p. 306) is the same as *Coccoseris* Cp. Lindström (l.c.).
25. *Stylaræa* M.-E. & H. (Klunzinger, Kor. des Rothenmeeres, ii. (1879) p. 43. Merged in this Catalogue with *Porites* (Vol. V. in preparation).
26. *Synaræa* Verrill (Bull. Mus. Comp. Zool. Camb. Mass., 1864, 3, p. 42). Merged in this Catalogue with *Porites*.
27. *Thecia* M.-E. & H. (C.R., xxix. (1849) p. 263). According to Miss Ogilvie (Phil. Trans., clxxxvii. p. 339) allied with *Protaræa*, *Coccoseris*, etc.
28. *Tichopora* Quelch (Chall. Rep., xvi. (1886) p. 188). Here merged with *Goniopora* (see p. 16).

The Genus GONIOPORA.

(= *Astræa* Lamarck *partim*; *Goniopora* Quoy and Gaimard; *Goniopora* + *Rhodaræa* + *Litharæa* Milne-Edwards and Haime; *Goniopora* + *Rhodaræa* + *Tichopora* Quelch).

I. HISTORICAL.

(*a*) Goniopora.

THE genus *Goniopora* is usually accredited to Quoy and Gaimard who described * under this name, in 1834, a reef coral found at Port Dorey, New Guinea. They introduced the genus, however, as "*Goniopora* Blainville." The latter author evidently suggested the name, for he tells us that Messrs. Quoy and Gaimard, misled by the resemblance of the coral to an Astræid, proposed to call it *Astræa pedunculata*. But when they recognised that the tentacles were long and in a single ring, and that the calicles were not at all lamellate or star-like, but on the contrary eminently porous and echinulate, they established a new genus allied to, but distinguished in the form of the animal from *Alveopora*.

The name *Goniopora*, further, was actually first published by de Blainville in 1830 (Dict. Sci. Nat., lx. p. 359). He referred to it as due to Messrs. Quoy and Gaimard, with whose names the genus has ever since been associated. That these authors should have been disposed to class the new coral with the Astræids will be the more readily understood when we remember that at least one of Lamarck's Astræids, viz. *A. calicularis*, was a *Goniopora* (*Rhodaræa* M.-E. & H.).

The original definition of Quoy and Gaimard described the animals as "actiniform," long, cylindrical, with a crown of more than a dozen simple, rather long tentacles; further, the calicles were polygonal, irregular, with echinulate margins, the stocks being glomerate, rounded, encrusting, and very porous.

This definition was slightly amplified by de Blainville: "The calicles are irregular or unequal, their walls somewhat strongly grooved on the inner side, and they are united side by side or above one another, forming an extremely porous non-fasciculated corallum," i.e. the individual calicles are not recognisable in the fractures.

De Blainville added no new "species" to the single type specimen called *G. pedunculata* † Q. & G.

In 1834, the new genus was hesitatingly suppressed by Ehrenberg ('Corallenthiere des

* Voyage de l'Astrolabe, Zoophytes, iv. p. 218.

† This name would apply equally well to at least 30 per cent. of the known members of the genus (see Plates XI. and XII.).

rothen Meeres,' p. 155), for on p. 98 he suggested that the *Astrææ* might be divided into two subgenera: (1) *Astrophyllia* with solid lamellate septa; (2) *Goniopora* with septa perforated, ragged and discontinuous, carrying rows of teeth. While again, on p. 107, he seems to have hesitated as to whether *Goniopora* was the same as *Astræa* or *Porites*.

The type species *G. pedunculata* does not appear either among his *Astrææ* or his *Madrepora-porites*.

In 1848, Dana (Zoophytes, p. 549) placed *Goniopora* with *Porites*, the two forming the family Poritidæ (see above, p. 4). This, however, was not done without some hesitation, for on p. 407 there occurs a note to the effect that the genus *Goniopora* might possibly belong to the Caryophyllacea, occupying a place in that tribe corresponding to the place of *Porites* in the Madreporacea. The two genera were said to differ in size of polyps. In *Porites*, they are small (average 1 mm.) with only 12 tentacles, but large (2–4 mm.) in *Goniopora*, with 16–24 tentacles. In *Goniopora* the calicles are often much deeper than in *Porites*.

The genus *Goniopora*, according to Dana, who only found one new "species" called "*G. columna*" from Fiji, only occurs in the Pacific and Indian oceans. At the same time he suggested that the coral from the Red Sea figured by Savigny (Descr. de l'Égypte, pl. v. fig. 2) might also be a *Goniopora*.

According to the first published opinion of Milne-Edwards and Haime,* the Goniopores were Astræids with fenestrated septa, and divisible into two genera *Goniopora*, with obsolete † calicles, and *Porastræa* with deep calicles. The walls were described as spongy, and the stock as increasing by budding and provided with a thin incomplete epitheca. On founding their Madreporaria perforata ‡ they accepted Dana's family Poritidæ with *Porites* and *Goniopora*, thus dissociating the latter entirely from the Astræids. On the position to which they assigned the family see above, p. 4. The name *Porastræa* disappeared with the idea which it embodied, and the genus became *Goniopora*. The words "fenestrated septa" also disappeared in favour of "trabecular septa" in accordance with their morphological theory as to the origin of the Madreporarian skeleton. On these points see above, pp. 4 and 5. Their amended description of the genus, which seems to limit it to forms with deep calicles and thin walls, ran as follows:—

Epitheca rudimentary, walls distinct, raised, fenestrated, and simple, calicles deep, columella spongy and irregular. Usually three cycles of septa which are *distinct*, formed of somewhat large trabeculæ especially internally, where in "young" and marginal calicles they form a ring of pali-like lobes. These entirely disappear in the "adult" calicles. (On this last point as to whether the marginal or the central calicles are the older, see below, p. 27.)

The nearest related genera were said to be the fossil *Litharæa*, a new genus *Rhodaræa* § and *Alveopora*.§ The first was said, quite erroneously, to have less trabecular septa, i.e. more

* C.R., xxvii. (1848) p. 496.

† The authors were apparently misled, because the type of their *Goniopora* is "*G. pedunculata*" Q. & G., which has deep calicles.

‡ C.R., xxix. (1849) p. 258; and Ann. Sci. Nat., xvi. (1851) p. 21.

§ On the position assigned to these genera in this Catalogue, see list, p. 9.

nearly lamellate septa than *Goniopora*; the second to differ in the persistence of well-developed pali-like lobes; and the last to be an extreme form, a kind of exaggeration, of *Goniopora*.

Milne-Edwards and Haime accepted seven "species," one with hesitation. These were (1) the type species, "*G. pedunculata*" Q. & G.; (2) "*G. viridis*" (= *Ast. viridis* Q. & G.); (3) "*G. lobata*" (new); (4) "*G. Savignyi*," suggested by Dana; (5) "*G. Stokesii*" (new); (6) "*G. columna*" Dana; (7) "*G. lichen*" (= "*Porites lichen*" et "*reticulosa*" Dana). This last suggestion Prof. Verrill, who worked over Dana's types, did not admit.

No change was made by Milne-Edwards when, after the death of Haime, he published the third volume of the 'Hist. Nat. des Coralliaires' in 1860.

In 1872, Professor Verrill * regarded the genus as closely related to *Alveopora*, differing chiefly in the twenty-four radiating septa. The genus was further said to combine many of the characters of *Alveopora* and *Porites*. He finally classed it with *Alveopora* and *Litharæa* in a sub-family Alveoporinæ.

Further, in the appendix to Dana's 'Corals and Coral Islands' Professor Verrill rejected the suggestion that the *Porites lichen* and *Porites reticulosa* of Dana belong to the genus *Goniopora*.

Brüggemann only referred to the genus in a paper which dealt with some Stony Corals from Singapore.† He described a new "species" *G. malaccensis*,‡ and added a few notes on the accepted species of Milne-Edwards and Haime. He further declared that these authors were quite wrong in speaking of the shallower calicles at the sides of the stock which have the rings of pali as the younger, as they do in their descriptions of "*G. pedunculata*," "*G. lobata*," and "*G. Savignyi*." Evidently referring solely to columnar forms, Brüggemann argued that the growth "being terminal" the lateral calicles must be the oldest, being pushed outwards by the buds developing at the tip in the axis of the stock. In these one would, he thought, naturally expect a more pronounced deposition of skeletal substance and consequent thickening of the septal apparatus (on this disputed point see below, p. 27).

From the order in which Brüggemann described the corals dealt with in this paper we can gather that he accepted the position assigned to the genus by Dana and Milne-Edwards and Haime.

This same position of the genus was again accepted by Dr. Klunzinger ('Korallenthiere des rothen Meeres,' 1879). He identified "*G. lobata*" M.-E. & H. with "*Astræa planulata*" of Ehrenberg. He also figured (by photography) and described from fresh specimens a form which he believed to be the same as that figured in Savigny's 'Égypte' and called by Dana "*G. Savignyi*," and another small encrusting form as "*G. lichen*" M.-E. & H. which he doubtfully identified with the "*Porites lichen*" of Dana. Professor Verrill's pronouncement on this point (see above) was apparently overlooked. Lastly Dr. Klunzinger (l.c.

* Amer. Journ. Sci., iii. p. 194; reproduced in Ann. and Mag. Nat. Hist. (4) ix. p. 355.

† Abh. Naturwiss. Ver. Bremen, v. (1878) p. 539.

‡ The type specimen of which apparently became the property of the British Museum (see pp. 80 and 81).

p. 47, footnote) suggested that another of Savigny's splendid figures, *Porites "clavata* Aud.,"* the mysterious coral on pl. iv. fig. 6 of the Description of Egypt, was also a *Goniopora* (see below, p. 99).

It has further to be noted that Dr. Klunzinger, who refers several times to Brüggemann's paper quoted above, rejects the criticism of that writer and reaffirms that the deeper calicles are the older, and the shallower lateral calicles are the younger.

In 1878, Professor Studer† adhered to the classification of Milne-Edwards and Haime He described no new "species" but recorded "*G. pedunculata* Q. & G." from the Solomc Islands, and "*G. columna* Dana" as plentiful in Holzhafen, New Ireland.

In 1884, Martin Duncan's‡ revision of Milne-Edwards and Haime's system of Madreporaria contained no essential change in the position of the genus. It was said to differ on the one hand from *Rhodaræa* in having "no pali" and endotheca, and on the other from the fossil genus *Litharæa* in the feeble development of the septa. These three genera beginning with *Rhodaræa* lead on, with the intervention of the fossil genus *Protaræa*§ M.-E. & H., to *Alveopora*.§

In 1886, Mr. Quelch in his 'Challenger' Report on the Reef Corals, placed *Goniopora* as the fourth genus of the *Poritidæ*. Only three representatives of the genus were discovered by the Expedition and these were named *Goniopora pedunculata* (see below, p. 70 and p. 37), *Rhodaræa tenuidens* (see below, p. 69 and p. 15), and the third was thought to be a type of a new genus *Tichopora* (on this see p. 16).

In 1888, Dr. Ortmann‖ described a new "species" *G. parvistella* and placed the genus after *Rhodaræa* and before *Alveopora*, thus accepting the usual position assigned to it among the Poritidæ. In his later work on the classification and phylogeny of the Stony Corals¶ the genus was not referred to.

In 1891, Mr. Saville-Kent** described and figured a new and previously quite unknown form, viz. one with thin branches, as "*Goniopora fruticosa*"; but in 1893, in 'The Great Barrier Reef,' he preferred to call it "*Rhodaræa fruticosa*." He further called attention to the remarkable variety of colour displayed by the polyps.

In 1896, Miss Ogilvie†† followed Milne-Edwards and Haime in the place assigned to the genus, but did not discuss it apart from the family. In the same year, Dr. G. v. Koch‡‡ figured the structure of the skeleton of a "*G. molluccensis*" (= ? *G. malaccensis* Brüg.) showing a simple wall.

In 1898, in discussing the relationship between this genus and *Alveopora*, the present writer§§ analysed its so-called trabecular structure, and showed that its "trabecules" could

* Audouin wrote *P.* "*clavasia* Lamarck," whereas Lamarck's type was *P. clavaria*.
† MB. Akad. Berlin (1878) p. 524. ‡ Journ. Linn. Soc. Zool., xviii., p. 189.
§ For the positions of these genera here adopted, see list, p. 9.
‖ Zool. Jahrb. (Syst.) iii. p. 143. ¶ Op. cit., iv. (1889) p. 493.
** Rec. Austral. Mus., i. p. 123, pls. xv. and xvi. †† Phil. Trans., clxxxvii.
‡‡ Gegenbaur's Festschrift, ii., p. 251; also Morph. Jahrb., xxiv. p. 170.
§§ 'Recent Poritidæ,' Journ. Linn. Soc., xxvii. p. 127.

not be considered to be of any value as morphological units. *Goniopora* and *Porites* were the two genera of the Poritidæ and deducible from Madreporids; *Porites* being the primitive form and *Goniopora* to be derived from *Porites* by simple enlargement. At the same time Dana's suggestion (see above, p. 11) is quoted that the genera may be parallel and analogous off-shoots from different ancestral forms.

In the following pages it will be shown that *Goniopora* is the more primitive, and that *Porites* can be deduced from it by a simple process of reduction of its septal formula.

In the foregoing historical sketch of our knowledge of the genus *Goniopora*, no fossil forms have been recorded. This was one of the reasons which led me to think that the genus was more recent and even a possible derivative of *Porites*. As a matter of fact, *the large and important group called "Litharæa" consists solely of fossil Goniopores.* The distinction drawn by Milne-Edwards and Haime between *Litharæa* and *Goniopora* was based upon insufficient material.

(*b*) Litharæa M.-E. & H.

This genus was founded in 1850 by Milne-Edwards and Haime,* for a Poritid found in great numbers at Bracklesham Bay, Sussex, and first described and figured by Bowerbank in 1840† as an Astræid ("*Astrea Websteri*").

In the same year as the genus was founded, Lonsdale‡ described it as a *Siderastræa* (*S. Websteri*).

It was diagnosed by Milne-Edwards and Haime as differing from *Goniopora* in the fact that its septa were not so "trabecular," and in this respect, viz. in the possession of more completely solid septa, it was thought to approach the Astræids. It accordingly occupied in their system one extreme of the Poritidæ, while *Alveopora* with its spinous septal ingrowths occupied the other. On the supposed absence of the pali, see p. 146.

This arrangement is purely artificial. Genera cannot of course be founded on characters which differ only in degree. A generic character must express some essential difference of structure, and any such difference between *Goniopora* and *Litharæa*, I have failed entirely to find.

Since 1850 many fossil Gonioporas have been described as *Litharæa* or *Porites*. The dictum of Milne-Edwards and Haime that *Goniopora* was a recent form, seems to have been blindly followed, for no suggestion seems to have been made that the very porous septa of some of these *Litharæas* constituted them true *Gonioporæ*.

That many of them should have been classed as *Porites* is due to the fact that the

* Brit. foss. Corals, p. 38, pl. vi. fig. 1.

† 'On the London Clay Formation,' Charlesworth's Magazine of Natural History, new series, iv. p. 24; figures in text.

‡ In Dixon's 'Sussex,' p. 138, pl. i. fig. 5.

distinction drawn by Dana between *Goniopora* and *Porites*, viz. that the former were larger with twenty-four septa while the latter had only twelve, has not been found satisfactory. Fossil perforates are found with all numbers from twenty-four and more, to twelve and fewer and yet having all the distinguishing characters of true *Poritids*. This distinction is nevertheless useful and is often followed here. An important morphological distinction recently discovered by the present writer and described below, p. 20, is not always available, and then recourse must be had to the older distinction, based simply upon the number of the septa.

Over 40 fossil forms of *Goniopora* had thus been described under various names. Reuss alone described and figured 14, while others occur in the works of Michelotti, Catullo, d'Achiardi, Martin Duncan, Martin, Sismonda, Posta and Angelis (see Table II. p. 168).

The histories of two other genera, merged with *Goniopora* by the present writer, viz. *Rhodaræa* M.-E. & H., and *Tichopora* Quelch, have still to be given.

(*c*) Rhodaræa.

This genus was founded by Milne-Edwards and Haime in 1849 * for the *Astræa calycularis* of Lamarck, which became "*Rhodaræa calycularis*" M.-E. & H. It found its place among the Poritidæ next to *Goniopora*. This latter genus was described as having walls distinct, elevated and fenestrated, with well-developed fenestrated septa, spongy columella, without pali (see p. 152); whereas *Rhodaræa* was said to have thick walls which are only slightly elevated, with rudimentary septa, and pali very well developed and forming a rosette in the middle of the calicle.

According to this description, and apparently on account of the lower wall and well-developed pali, *Rhodaræa* was placed between *Porites* and *Goniopora*. This order was maintained in the 'Monograph of the Poritidæ.' † In 1860, in vol. iii. of 'Les Coralliaires,' by Milne-Edwards alone, two fossil genera *Protaræa* (Silurian) and *Litharæa* (Eocene) intervene between *Rhodaræa* and *Goniopora*, which last was said to lead on to *Alveopora*.‡ If the series was mainly based upon the height and character of the walls we should logically be compelled to complete it by placing the genus *Synaræa* of Verrill in the first place because these are Poritid forms in which all traces of raised walls are obliterated. The order is mainly interesting because it shows that the genus *Goniopora* was supposed invariably to have tall thin walls.

In the monograph above quoted,§ the authors added two more "species": *Rh. lagrencii* (doubtful) and *Rh. raulini* (foss. Miocene) and in 1860,‖ a fourth *Rh. gracilis*.

The next mention of the genus was in 1878 by Brüggemann. ¶ This author described a

* C.R., xxix. p. 259.
† Ann. Sci. Nat. (3°) xvi. 1851.
‡ On this, see p. 2 of this volume.
§ Ann. Sci. Nat. (3°) xvi. p. 43.
‖ 'Les Coralliaires,' p. 184.
¶ Abh. Ver. Brem., v. p. 547.

specimen from Singapore as "*Rhodaræa lagreneii*," and further identified it with the coral figured by Savigny, Desc. de l'Égypte, pl. 4, fig. 6, called *Porites clavaria*.*

Professor Studer followed Brüggemann in including a "*Rh. lagreneii*" among the Singapore corals and stated that he had found a similar "species" in New Ireland.

The position assigned by Martin Duncan to this genus has already been mentioned above in the history of the genus *Goniopora*, where mention is also made of the references to the genus by Mr. Saville-Kent.

See also under same heading for the results of the 'Challenger' Expedition as regards this genus.

In 1888, Dr. Ortmann† described the difference between *Goniopora* and *Rhodaræa* to be that, while in *Rhodaræa* in the "younger, deeper, central" calicles, the pali are distinct, in the "older (lateral)" calicles septa and pali fuse into a homogeneous spongy mass; in *Goniopora* the reverse is the case, the pali are distinct in the "older" (lateral) calicles and obliterated in the "younger" (central) calicles.

In 1890, Mr. Bassett-Smith‡ noted two forms which he had discovered in the China Seas. They are here described on pp. 72 and 73.

In 1895, two fossils were attributed to the genus by Dr. Angelis§ and named *Rh. ambigua* and *Rh. dissita*, see pp. 121 and 113.

The proposal to merge this genus with *Goniopora* was first made by the present writer in 1899‖; the usual distinction having been found to be a matter merely of degree, and hence of insufficient morphological importance (see further next paragraph).

(*d*) Tichopora.

This genus was proposed by Mr. Quelch¶ for a single small specimen from Samboanga. It was said to differ from *Goniopora* in that its walls were only slightly developed, and did not rise as strong distinct trabeculate laminæ; and, further, in having paliform spinules more distinct in the central than in the lateral calicles. From *Rhodaræa* it differed in the comparative indistinctness of the paliform spinules. As these differences are mere questions of degree as soon as a large collection is examined, this genus was also merged in the extended genus *Goniopora* by the present writer in the paper above quoted.‖ It will further be shown lower down (see section on the morphology of the skeleton) that all massive Gonioporas are Rhodaræas at the sides!

* On the various attempts which have been made to specify this coral, see the introductory remarks to the Red Sea forms (p. 99).

† Zool. Jahrb. (Syst.) iii. p. 158.

‡ Ann. and Mag. Nat. Hist. (6°) vi. p. 457.

§ Atti R. Accad. Lincei (5°) i. p. 164.

‖ Journ. Linn. Soc., xxvii. p. 144.

¶ Challenger' Report, xvi. 1886.

II. THE POLYP AND ITS ANATOMY.

All observers are in accord in describing the polyps as being very extensile. Two sets of figures are given by Quoy and Gaimard.* In the form called "*Goniopora pedunculata*" the extended polyp is very tall and cylindrical with a crown of 24 tentacles alternately longer and smaller. In the form called "*Astrea viridis*" the polyps are very large, slightly tapering, and regularly constricted at intervals all the way up. The tentacles are 48 in number and again alternately larger and smaller. Other figures are given by Dana and by Mr. Saville-Kent, the tentacles being shown by the latter as long and tapering. Many of these differences of shape are probably accidental. Another difference, evidently dependent upon the height of the walls, is seen in the different degrees of retraction. In the very deep calicled forms (see *G. Java Sea 1*, Pl. VIII. fig. 4) the polyp retracts deep down into the base of the pit. Quoy and Gaimard described the retraction in their form "*G. viridis*" as complete. Professor Studer, on the other hand, records the inability of the polyps of his "*G. columna*" from Holzhafen, New Ireland, to withdraw completely into their calicles.

The tentacles are mostly 24 in number and in a single ring, but more are occasionally to be found. Many of the fossil forms show by the number of the septa that they had more than 24, while the form "*G. viridis*" Q. & G. is very plainly figured with 48. A number less than 24 is also common especially among the fossil forms.

An observation of Dr. Klunzinger's requires further explanation. He describes the form which he names "*G. planulata*," from the Red Sea, as having 24 tentacles *in* 2–3 *rows*. If the observation was made on spirit specimens the appearance could be accounted for by contraction. The "*G. columna*" of Dana, which Dr. Klunzinger suggested as synonymous, was, as noted above, figured with a single row of tentacles.

I know of no record of any anatomical researches into the soft parts.

The records of colour are given in the descriptions; they are, unfortunately, too few to be of any use in the tabulation of variations given at the end of the systematic portion (Tables III. *et seq.*) A few examples are given by Mr. W. Saville-Kent in his 'Great Barrier Reef,' chromo plate vi.

III. THE MORPHOLOGY OF THE SKELETON.

Regrets are often expressed that we possess as a rule merely the dried skeleton remains of the Stony Corals. These regrets I do not share, in so far, that is, as they imply that very little can be obtained from them. I am disposed, on the contrary, to think that with reference to most of the small calicled colonies the skeletons are not only the most important parts of their organisation, but that they are parts which follow the growth of the polyps closely enough to be able to register in some way or other all but the most superficial colour variations of the

* 'Voyage de l'Astrolabe,' Atlas Zooph., xvi. figs. 1–3 and 9–11.

living tissue. This is probably more especially true of the porous forms, for a finely reticular skeleton is obviously better adapted to follow the modification of living tissue than one constructed of stiff plates. These remarks are, however, thrown out tentatively, for little as we know about the method of the secretion of the skeleton by the ectoderm, we know absolutely nothing of the physiological stimulus which causes it here to secrete and there not to secrete, a differential action which leads to all the varying patterns of the skeleton.

The fundamental character of the Skeleton of Goniopora.—The skeleton is porous because constructed on the same general principle as that of the Madreporidæ. The primitive epithecal cup or prototheca of the Madreporaria has been flattened out, and become vestigial, and the present thecæ are entirely septal and internal.*

This internal skeleton is usually described as "trabecular," that is, its principal elements, the septa, are supposed to be built up of trabeculæ or skeletal rods arranged as a lattice-work. This, however, is not a very accurate description. It is true that the septa are usually very perforate (see Pl. III. fig. 2) but nothing is gained by describing a perforate lamella as being composed of the strips of tissue running between the perforations; for it is the septa which are the morphological units and not these intervening strips. The term trabecula is, however, too useful to be altogether discarded, and it is here used in the same sense as in Vol. III., viz. in descriptions of texture, sometimes to denote the thick and prominent skeletal strands which run in the direction of growth, the tips of which, appearing at the surface, e.g. on the tops of walls and along the upper edges of septa, form granules and spikes.

The Vestigial Epitheca.—In accordance with the origin here assigned for this family, viz. as due to the fixing of a perforate i.e. purely septal skeleton at an immature stage when the theca is low and shallow, we should expect to find more conspicuous traces of the epitheca than in the Madreporidæ proper. For a vestigial structure would naturally be a more conspicuous element in a rudimentary stage of skeletal development such as we have in *Goniopora* than in the case of a skeleton which towers up, and whose buds appear high up above all contact with it. Explanate Madreporidæ have their free edges usually shooting far beyond the supporting epitheca. But in *Goniopora* and in *Porites*, the supporting epitheca takes the lead in the formation of the edge and is frequently seen projecting, e.g. Pl. III. fig. 6.

The growth-forms of *Goniopora* are, for reasons which will be explained below, very rich in free edges; consequently bands of wrinkled epitheca are a conspicuous feature in most colonies. See further below on the tabulæ, which are also related structures.

The Theca.—Above the flattened epitheca rises the new theca or wall built up of the septa united by synapticulæ, and hence necessarily porous. In the majority of cases it is not easy to define which part of this porous mass constitutes the wall, because there is generally more than one ring of synapticulæ, and even when only one ring is developed, the septa usually carry incipient synapticulæ whose further growth would immediately thicken the theca and change it from what is here called a "simple" into a "compound" wall.

The statement of Dr. Klunzinger, repeated by Martin Duncan (see Historical Review, *supra*,

* Cf. Journ. Linn. Soc., xxvii. p. 487.

p. 6), that the walls are united directly, and not by cœnenchyma, has little real meaning. Cœnenchyma is the porous tissue between the adjacent calicles of porous corals and these united walls themselves form the cœnenchyma. It is quite wrong to regard the fusing walls of a Madrepore as cœnenchyma merely because the rims of the calicles tower above the level of fusion, while looking on the fusing porous walls of *Goniopora* or *Porites* as only fused walls and not cœnenchyma. The cœnenchyma in *Goniopora* is reduced to a minimum when the wall is a mere perforate membrane, and it reaches a maximum when the fossæ are most widely separated by porous tissue.

We may call the wall that portion of the theca which rises the highest, for there the synapticulæ are always found uniting the septa in one or more rings forming respectively simple or compound walls. We may divide the thecæ into two types, regular and irregular.

The regular theca is that in which the septa are symmetrically radial, and the synapticulæ more or less regularly concentric. This regular type may be regarded as the primitive type of the parent calicle of the genus.

Under the irregular types come all the other forms of calicles due to irregularities in the radial arrangement of the septa, or in the concentric arrangement of the synapticulæ which are found within the genus and which can all be deduced directly or indirectly from the regular or primitive type.

The Primitive Calicle.—In addition to the regular radial arrangement of the septa, the other chief characteristics of this parent form were as follows. The theca was low and thick, the fossa shallow, the septa fused according to a formula presently to be described, and the columellar tangle was conspicuous in the floor of the fossa, and from it a rosette of six paliform knobs arose. This primitive type of calicle is that which was supposed, on account of this rosette, to distinguish the genus *Rhodaræa,* but as it plays an important part in the detailed description of nearly every representative of the genus it could not possibly form a generic distinction. It reappears almost invariably on what are called the "free edges" of colonies, no matter how specialised the calicle structure typical of those colonies may be, so that all massive Gonioporas are Rhodaræas at the sides! The significance of this tendency of laterally placed calicles to revert to the primitive type will be discussed in the paragraph on the Growth-forms.

Modifications on this Primitive Calicle.—The theca being built up of septa united by synapticulæ, varies with any variation in either of these two factors.

If the top edges of the septa are all on a level, there is then no raised wall, and the calicles are said to be "obsolete" or flush with the surface. But in the great majority of cases the wall is raised, and this raising reaches an extreme when one thick trabecula rises up from the peripheral end of each septum, and is united to its fellows by broad band-like synapticulæ, so that the wall is tall, membranous, and perforated.* (Cf. e.g. Pl. VIII. fig. 4.)

The synapticulæ joining the wall portions of the septa should perhaps be called the wall proper, being the concentric elements. But they are not always symmetrically concentric,

* The tall thin wall was the characteristic of the limited genus *Goniopora* M.-E. & H., 1851 ('Les Poritides,' p. 38).

often melting down with the septa into a reticulum, and further they are septal structures, and in matter of mere bulk frequently insignificant as compared with the parts contributed by the more radial portions of the septa; hence, as stated above, we call the wall, the whole of the skeleton which forms the rim of the theca.

The synapticulæ may form a single ring as in the case just cited. This may be uniform or it may show its composition out of so many separate synapticulæ by running in a zigzag round the calicle. If the synapticulæ do not come quite to the edge of the wall, the latter is denticulate, or, if the wall is thick, it is striated by septal ridges, these ridges being of course the homologues of the denticulations of the thin walls.

Lastly, the wall may lose all regularity in the arrangement of its radial and concentric elements, and may melt down to form a reticulum, and this reticulum may have many characters. It may be delicately filamentous, Pl. II. fig. 9; or composed largely of flakes. When these flakes lie horizontally we get such an extreme form as that shown, Pl. V. fig. 5; when they are arranged vertically we get a peculiar type, examples of which are shown in Pl. VII. fig. 1, Pl. VIII. fig. 1; in which the walls are composed of twisted vertical lamellæ. Many grades occur between these three extremes, the purely filamentous and the horizontally and vertically lamellate.

Other modifications of calicles are bound up with variations in the septa. But it may here be noted that when the walls melt down into a reticulum the septa are usually involved throughout their whole lengths, and we may have calicles in which all radial symmetry is obscured, the whole skeleton being little more than an irregular sponge-work * (e.g. Pl. VI. fig. 1). One modification on the primitive type occurs abnormally on a specimen from Celebes. It is figured Pl. IX. fig. 3. So far it is not known on any representative of the genus as its normal calicle.

The Septa.—The primitive calicle had 24 septa, which still persist in the great majority of the modern representatives of the genus. Even in those forms in which the calicles are most specialised and the number of septa reduced and their symmetry obscured, the typical number will usually reappear in the "lateral" calicles, or in those on "free edges," which, as above noted, tend to revert to the primitive type.

In certain fossil forms, however, in which we have no lateral calicles preserved for us to turn to, it is often extremely difficult to say whether there are 12 or 24 septa. We may have for instance 12 distinct plates radiating outwards from the centre and round these apparently a very thick reticular wall. It is difficult to decide whether this reticulum is all mural or due to the secondary fusion of the septa, the tertiaries coming in to complicate matters. In these cases there is only one certain method of deciding, and that is not always available. When a median continuous wall- or synapticular thread runs through this reticulum round the calicle

* Cf. the remarks made p. 146 on the Paris Basin forms. It is there suggested that the melting down of the skeletal elements, septa, and synapticulæ may be a protection against deposits of fine mud which might otherwise settle down into the interseptal pockets of the skin in retracted polyps and be difficult to dislodge.

and shows by its knotted or zigzag arrangement how many septa departed from it, then we know that the reticulum is a product of intramural septal fusions.

These fossils with the 12 central rays might almost be considered as transition forms towards *Porites*, having to all appearance only 12 septa; but whenever it can be distinctly seen that a certain number of these septa fork before they reach the wall, I assume that this forking is the vestige of the fusion of the septa characteristic of *Goniopora*, and that therefore there are more than 12. Cf. the diagrams A and B, and the figure 3 given on Plate X[a]. which will serve as one among many examples.

The three cycles which were present in the primitive parent fused together according to a regular formula which is seen in the earliest fossil representatives of the genus, and persists to this day, wherever the regular type appears or reappears, though it is frequently secondarily obscured in the specialised calicles. This formula is shown in the accompanying diagram (A) (see e.g. Pl. I. 3; Pl. IV. 9; Pl. V. 4; Pl. VI. 9; also the fossils, Pl. X[b]. figs. 5 and 7).

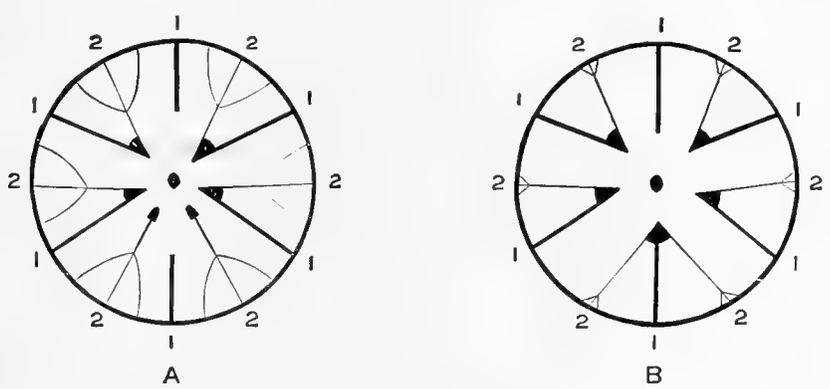

FIG. 1.—Diagrams to elucidate the underlying septal formula A of *Goniopora*, and B of *Porites*, to show how the latter may be derived from the former.

Two of the primaries are seen to be directives, while the remaining four fuse with four of the secondaries. The tertiaries fuse in pairs with the secondaries between them. The larger pali arise at the points of fusion of the septa, but seem to be associated more with the secondaries than with the primaries, for it is to be observed that while the directive primaries usually have no pali, the pair of secondaries which do not fuse with primaries have small pali. Whatever be the explanation, it is a fact which has been frequently noticed in the genus, that the pali seem to be usually associated with the secondaries. It is, however, doubtful whether this is invariably the case. For when the secondaries are feebly developed and the primaries are prominent, the teeth of the latter certainly bend up and supply the place of pali.

To diagram A I have added diagram B, in which the tertiaries are represented as disappearing. *Their final disappearance changes the formula typical of Goniopora into that of Porites.* When I described and figured this latter formula,* I despaired of finding any formula

* Journ. Linn. Soc., xxvii. (1900) p. 488.

for *Goniopora* at all. The majority of the figures will show how completely it is, as a rule, obscured, and I had not at that time discovered the tendency of the lateral calicles to revert to the primitive type (see below on the Growth-forms).

The directive septa are frequently reduced (cf. Pl. IV. fig. 9; in the uppermost calicle the plane of symmetry runs across the page, the right-hand directive is reduced, but in the lowest right-hand calicle the plane runs up the page, and both directives are complete). There may be a flattened central tubercle to indicate the directive plane, or else one of the directives may be greatly prolonged.

The upper and inner edges of the septa are denticulate, this being merely an expression of their perforate character.* This perforation may go so far as to reduce the septa to mere thin filaments: cf. the specimen described on p. 68 as *G. Philippines 2*, and for others see Table IV. p. 180.

The taller the wall naturally the steeper is the slope of the septa into the deep fossa. There is some correlation between this depth and the formation of pali. Deep funnel-shaped calicles show only slight development of these structures; they may be nothing more than the thickening of the edges of the principal septa (as in the upper calicles, fig. 5, Pl. VIII.) Deep cylindrical calicles, on the other hand, usually have pronounced pali, but feebly developed septa. It is common for such steep cylindrical walls to show hardly any trace of septa round their margins, and only deep down the principal septa suddenly project and, bending up, rise as plate- or rod-like pali high in the fossa. Both these types of calicle, however, tend, as we shall see, to pass gradually at the sides into the same primitive regular type with central rosette. The ragged inner edges of the septa always fuse in the centre to form:—

The columellar tangle: this is always present, but is obscured in deep funnel-shaped calicles. In these it usually consists of a loose tangle of filaments formed from the edges of the septa, but it tends to become a well-defined structure filling up a conspicuous place in the floors of shallow calicles. When well developed it frequently so involves the septa that their typical arrangement is quite obscured, and they are reduced to mere connecting pieces between columellar tangle and wall. The pali then no longer appear as upturned portions of the septa either singly or fused together, but, if at all, as raised portions of the columella. It is sometimes possible to trace a V-shape in them due to their origin at the points of fusion of the septa.

The pali: these are typically six in number, see above, diagram A, p. 21. Their chief variations have just been mentioned in describing the septa and the columellar tangle (see further, p. 145). The somewhat surprising fact, that the pali are associated with the secondaries rather than with the primaries has been already noted.

The tabulæ: these structures are very conspicuous in this genus and play an important rôle in colony formation. They are mere repetitions of the primitive epitheca, but no longer in contact with the substratum, being secreted instead as an intraskeletal plate shutting off that

* In fossils the top edges of the septa are frequently shown as moniliform, e.g. *Porites indica*, in Duncan's 'Sind Fossil Corals,' pl. v. fig. 12. But these are in most cases due to post-mortem alterations of the skeletal substance.

portion of the skeleton which is still supporting the living colony from that portion which the living tissues have abandoned. They may be very thin and often incomplete, but, like the epitheca, they are a constant factor in this genus. In Pl. III. fig. 2, they can be seen as faint curved lines running across the picture.

The Growth-Forms.—With a parent calicle such as we have sketched for the primitive *Goniopora*, with low thick walls and shallow fossa, great plasticity of colony formation was hardly to be expected. The normal symmetrical budding of such a calicle could only result in the formation of circular, slightly convex astræiform colonies. This was, therefore, the simplest and most primitive growth-form, and is exemplified by several fossil and recent members of the genus, while all the other known forms may be deduced from it.

The term "astræiform" is used deliberately. For the real distinction between an astræiform colony and other forms depends entirely upon the shape and growth of the individual calicles. If the parent calicle is capable of independent growth in height and can bud laterally above the substratum, branching forms will arise. These, as in the case of *Astræopora*,* may become massive by secondary submergence in cœnenchyma. But when neither the parent nor any daughter calicle is capable of independent growth in height, and all the buds have to develop either upon the flattened epitheca or in accidental interstices, and in the latter case are never able to rise independently above the general level, then we have an astræiform colony. Probably every one of the fundamental variations on the primitive skeleton of the Stony Corals has at one time or another produced its astræiform colonies. Many indeed seemed incapable of producing any other form of colony; hence the great numbers of the so-called *Astræidæ*, which will only be correctly classified when we have analysed the different structural types of their component calicles.

So far as growth-form is concerned, *Goniopora* (and *Porites*) may be regarded as astræiform perforates.†

Starting from what we have described as the primitive form of colony, viz. the circular slightly convex astræiform stock which would result from the normal budding of the primitive parent calicle, we find two clear lines of departure from this primitive form.‡

(*a*) They have become less convex, and growth has gone on round the edges, and the colony has become explanate.

(*b*) They have become more convex, and the colonies have become hemispherical and columnar.

Both of these have again produced secondary modifications, which we shall now have to consider, but before doing so we would point out that both these two principal diverging lines of colony formation coincide with two diverging types of calicle, and we are face to face with the problem, which variation depended upon which? Did the growth-form take the lead

* Ann. Mag. Nat. Hist. (6) xx. (1897) pl. ii. fig. 4.

† Compare Fromentel's name for the Poritidæ, "Polyastrées Perforés" [*sic*], mentioned on p. 5.

‡ For a more detailed division of the growth-forms than that here briefly sketched, see Table III. p. 169.

and modify the calicle, or was it the modification in the parent calicle which changed the shape of the colony ? *

Here we have simply to describe the facts. In the explanate colonies, the primitive type of calicle either persists, see Pl. II. fig. 1, Pl. VII. fig. 8, or the skeleton of the calicle gets more and more flattened down by a reduction of the skeletal elements into short, thick, vertical trabeculæ, the tops of which at the surface look like so many closely arranged granules. The colonies in this case get increasingly thin, and the calicles more and more obsolete. A series showing this may be seen in the following figures and in this order, Pl. IV. fig. 2, Pl. VII. fig. 1, Pl. IV. fig. 1, Pl. V. fig. 4; while a different kind of flattening of the calicle, viz. by the reduction of its skeletal elements into thin horizontal flakes, is also seen in another explanate growth, Pl. V. fig. 5.

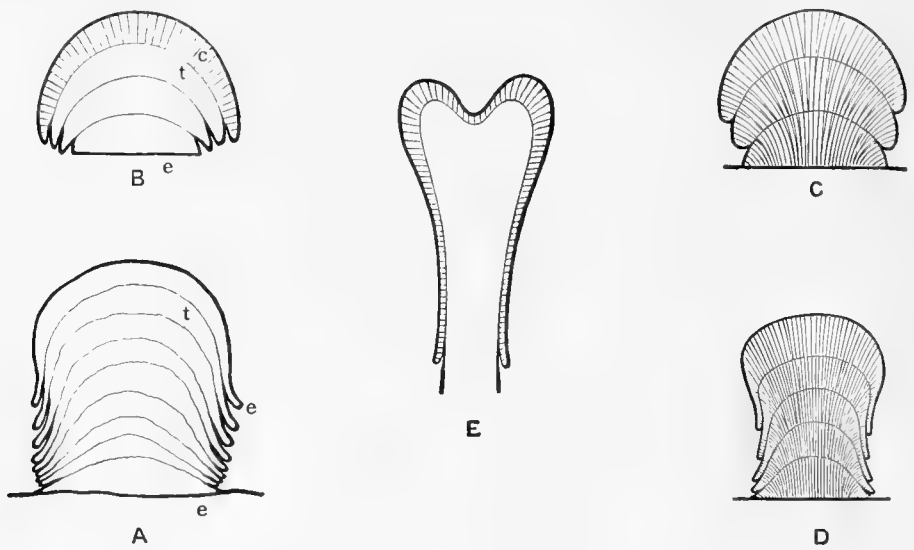

Fig. 2.—Diagrams to illustrate the different massive growth-forms with the free edges characteristic of this genus. The tabulæ (*t*) are shown in A and B continuous with the epitheca (*e*) under the free edges. A, general diagram; B, a simple hemispherical stock, with the calicles (*c*) of the living layer; C, the stock is a succession of cushion-shaped growths (pulvinate) of which the uppermost is alone living, and the two lower are bounded above by tabulæ. D, very rapid central growth forms an expanding column with straight sides (wheatsheaf formation); E, very rapid central growth resulting in a column, here shown forking.

In the other line of development, towards the formation of columnar stocks, the walls of the calicles in the centre of the colony grow in height, and according to variations in the speed and uniformity of this central growth we get all the known modifications of the massive type.

Fig. 2, diagram A, shows a stock apparently built up of a succession of colonies in which

* There is evidence that slight departures from the normal growth-form will seriously change the type of the calicle, see for example *G. Great Barrier Reef 7*; and cf. Pl. II. fig. 9 with Pl. III. fig. 1.

the walls of the central calicles have grown in height, while those (the youngest) round the edges remain nearer to the low-walled primitive type, not having had time to grow high. Interstitial buds naturally appear on the raised central portion owing to the enlarged surface. And this portion tends to rise at a still greater rate than do the edges, which expand laterally for a certain distance and then stop. Whatever be the reason for this, the lateral polyps round the edges of the stock seem to fail to develop in these massive forms. In the explanate stocks it is they which grow on, but in the massive forms it is those of the central regions which develop.

The polyps of this region rise in the lengthening calicles and secrete a tabular floor, and from this new level they usually throw out a new edge which covers up and kills the backward polyps round the original edge. The epitheca under the new edge is continuous with the tabular floor. This process results in massive forms. The central growth is continuous upwards through the stock, but there are a whole succession of edges one covering over the other and each with its supporting and often overlapping epitheca. Whatever be the specialisation of the deep central calicles, those on these free edges remain more like the primitive low-walled type, though showing that type somewhat modified according to the special modification of the central calicles. Not only do the walls remain thick and the fossa shallow, but the central rosette and the typical septal formula persists, though all these features are apparently completely lost in the peculiar specialisation of the central calicles.

This gives us a simple and satisfactory explanation of the free edges which are characteristic of this genus, and also of the fact that the "lateral" calicles of *Goniopora* always show so many of the chief characteristics of the primitive type.*

Secondary Modifications of the Explanate Growth.—Two modifications are shown by the specimens in the National Collection. Pl. XIII. fig. 10 shows an explanate stock on the surface of which small areas have been stimulated to rapid budding and to the throwing up of irregular columns, any parts of which can immediately readopt the explanate method of growth if they come in contact with any foreign body which they can encrust.

Pl. XI. fig. 9 shows an explanate growth the edges of which run out into lobes; these bend up, curl round into knobs or cylinders, and are left behind on the surface by the further growth of the edge. In one case certainly (*G. Great Barrier Reef 12*) and probably also in *G. China Sea 1*, branching tufts are formed in this way.

Variations on the Massive Growth-Form.—These may be numerous: so far they may be brought under five headings, and they appear to depend solely upon differences in the speed of growth of the central as compared with that of the lateral calicles.

1. Fig. 2, diagram B, shows the lengthening of the calicles as being fairly uniform, and there results a hemispherical or even globular mass, according as the edges hang down or curl under.

* These lateral calicles of massive stocks also show a great thickness in the skeletal elements, the columellar tangle frequently becoming quite solid. This is due to the fact that the whole of a perforate colony is practically one organism; the lateral calicles of massive forms thus become to all intents and purposes basal, and their skeletons are accordingly thickened.

2. The columnar form may be easily deduced from this by very rapid central growth and formation of tabular floors, so that in section it would look like a pile of caps of nearly the same size fitted into one another. The lateral edges may descend only a short way, or very far and be very thin, cf. fig. 2, diagram E. For a short edge see Pl. XIII. fig. 5; for a long edge see Pl. XII. fig. 13.

3. *The Pulvinate growth-form* (fig. 2, C).—This may not be normal, but simply an adaptation for the regeneration of injured surfaces of a stock. Assuming it to be normal, the calicles of the original stock all grow rapidly in length, even those round the edges, but without much lateral expansion. The first cushion-shaped mass is thus formed.

The uppermost calicles of this first stock still grow the fastest and tend to shoot above the rest of the surface and, as explained above, to throw out a new edge, see diagram A. A second cushion is thus formed.

There are no very young stocks showing this formation from the beginning, but such cushion-shaped masses are found, e.g. Pl. XI. fig. 5. Again, when the tops of great convex stocks have been killed down, one finds a group of calicles which has survived and continued to grow, forming a cushion-like mass upon the dead stock.

4. *The expanding Sheaf Formation.*—This is the most remarkable of all the growth-forms in the genus, and took a considerable time to unravel. The central calicles lengthen so rapidly that the primitive laminate septa seem to proliferate and to carry up the central region so fast that the skeletons of the calicles are a mere sheaf of long, twisted, nearly vertical laminæ sometimes so confused that the calicles opening among them lose nearly all traces of radial symmetry.* This shooting up of the septa as a sheaf of laminæ may, if moderately rapid, form a nearly rounded mass, see Pl. XI. fig. 6. The laminæ in this coral are shown in Pl. I. fig. 6. But when the growth is very rapid it results in a stock with straight sides sloping inwards towards the base: compare the diagram fig. 2 D, which represents my interpretation of the process; cf. further Pl. XIII. fig. 12, with its top calicles shown in Pl. VIII. fig. 1, and Pl. XIII. fig. 8, with its calicles on Pl. VII. fig. 4.

A further specialisation of this sheaf formation is described in the text, see *G. Red Sea 4*, and Pl. VII. fig. 9.

5. *Branching growth-forms.*—These forms will arise if the growth of the central region is irregularly distributed. The rising stock will then fork and produce branching clusters, either with long edges, fig. 2 E, also Pl. XII. figs. 12 and 13, or with short edges, Pl. XI. fig. 1.

In concluding this sketch of the chief morphological details discoverable from the known specimens it remains to be stated that by far the larger number of the specimens are shallow-water forms. The few which have been brought up from deeper parts of reefs justify us in

* In the large specimen of *Astræopora* figured in Vol. II. Pl. XXVI. the skeletons of the calicles are here and there composed of confused clusters of twisted laminæ running out into flame-like arrangements and obliterating the radial symmetry of the calicles. These are clearly analogous phenomena.

believing that the genus is far richer in variations than those which we have been able to record here. We have, however, discovered enough to settle the old controversy mentioned in the historical review, see pp. 11 and 12, as to whether the uppermost or the lateral calicles are the older or the younger. The problem was rendered of special interest owing to the remarkable and unaccountable structural differences between them. The belief that this difference was a mere question of age was a perfectly natural one. This we have now been able to show not to be the case. If, however, we now put the question, where are the youngest calicles to be found? the simple answer is, where the last budding took place. This would be in most cases at the tops of the stocks where growth is most rapid, but it might at any moment be at the sides if a new edge was being formed. But the budding on the top does not produce the same kind of calicle as the synchronous budding at the sides, for the former produce the specialised calicles characteristic of the specimen, and the budding of the edges produces calicles of the low, thick-walled primitive type. These latter, however, are modified so as in most cases to show their genetic affinity with those of the central region.*

IV. ON THE POSITION OF THE FAMILY AND GENUS IN THE MADREPORARIAN SYSTEM.

The eight years' study which the present writer has given to the family Poritidæ and the allied Madreporidæ has convinced him that both these families are to be deduced from some form or forms in which the septa rose from a flattened epitheca, as originally explained in 1898.† But working at that time chiefly with the genus *Porites*, he was disposed to regard it as the primitive Poritid genus and as consisting of colonies of Madreporids, the skeletons of which remained in a rudimentary condition, owing to very early budding. This, it was suggested, would account on the one hand for the poor development of the septa and the extraordinary shallowness of the calicle, and on the other for the fact that the polyps rise high above the skeleton and are unable to completely retract below the level of the walls. The genus *Goniopora* might be deduced, it was thought, by secondary increase in size; although the possible truth of the suggestion made by Dana ('Zoophytes,' p. 407) was admitted—that *Goniopora* might have had a separate origin, viz. from some Caryophyllid Dana (= Eupsammiid M.-E. & H.), among which it would hold a place similar to that occupied by *Porites* among the Madreporaceæ. If this were so, the family would be an artificial one. My present view is that the genus *Goniopora* is the more primitive, and may be regarded as made up of astræiform colonies of some simple Eupsammiid, and that *Porites* is derived from it (see Sec. III. p. 21).

The study of the fossil forms of *Goniopora* lends strong support to this view. Many of the early forms, viz. the two from Sind called by Duncan "*Litharœa epithecata*" and

* For further morphological details see Analytical Tables III. and IV.

† Jour. Linn. Soc., xxvii. p. 128.

"*Litharœa grandis*," show a very primitive colony formation, merely small convex mounds on a flattened circular epitheca. This is the simplest form of growth we can imagine, and I assume it to be primitive and just such as would arise from the early budding of an Eupsammiid, that is of some parent calicle in which the primitive epithecal wall had been flattened out and the theca consequently built wholly of septa remaining low and joined into a reticulum by synapticulæ. The only corals we know of any size which would supply such a parent calicle are the Eupsammiidæ. For instance, an astræiform arrangement of young *Stephanophyllia*-like calicles with only 24 septa would yield a typical Gonioporan colony.

In agreement with this origin it is interesting to find in the septal formula of *Goniopora* a uniform tendency to the fusion of lower cycles with higher, which is one of the characteristics of the Eupsammiidæ (cp. *Dendrophyllia*). The Eupsammiidæ and *Goniopora* appear to have arisen in the mesozoic times, the earliest known Goniopore being from the lower cretaceous of the Crimea, since which time the perforate corals have flourished, belonging for the most part to the tertiary period. No coral said to date from still earlier times and claimed as a Poritid has so far borne the test of examination, that is, of the examination made for this volume and after five years' study of the group (see the list, p. 9).*

With this origin it is possible to sketch the relationships of the genus with other perforate corals. We start with a parent form not unlike some simple *Stephanophyllia* with its epitheca flattened and its theca formed by septa, joined by synapticulæ and fusing according to a fixed formula. The larger and simpler forms of these corals persist and constitute the modern Eupsammiidæ. Single forms persist in *Stephanophyllia* and *Balanophyllia*; branching forms in *Dendrophyllia* and *Cœnopsammia*; while the special genus we are dealing with, *Goniopora*, may be regarded as consisting of astræiform colonies of the same, arising by very early lateral budding, that is, before the porous septal skeleton rising on the flattened epitheca has grown to any height. *Porites* may be derived from *Goniopora* by still earlier lateral budding, for, as shown above, the septal formula of *Goniopora* passes into that of *Porites* by the gradual suppression of the tertiaries without any change in order of the septal fusions seen in *Goniopora*.

With this origin for *Goniopora* and *Porites*, we have cut them once more adrift from the Madreporidæ with which we connected them, so long as we thought *Porites* to be the primitive Poritid. For the origin of the Madreporidæ we again look to the Eupsammidæ, unless we assume that the epitheca flattened out more than once independently. There is no need for this assumption. The Madreporidæ can easily be deduced from dwarfed Eupsammids in which the tendency to rapid growth in height early asserted itself, and the buds were produced above the epitheca and the substratum.

* What appeared to be a perforate coral from the Silurian was described and figured by Lindström, *Calostylis*. But my own examination of the specimens of this coral in the British Museum has convinced me that it is not a true perforate. Its position in the coral system will be dealt with in a paper on the coral skeleton which I have in course of preparation.

These different relationships are illustrated in the following scheme.

A primitive porous Coral, that is, a parent form in which the epithecal cup, or the prototheca, is flattened out and the secondary theca is built of septa joined by synapticulæ.

Simple and simply Branching Forms,	Luxuriantly Branching Forms, owing to early budding and consequent dwarfing of the polyps, but with rapid growth in height of theca,	Astræiform Colonies, due to early budding while the skeleton is incomplete, basal and disk-shaped,
THE EUPSAMMIIDÆ. [? Including TURBINARIA.]	**THE MADREPORIDÆ.** [? Excluding TURBINARIA.]	**THE PORITIDÆ.** GONIOPORA.
		By suppression of tertiary septa, PORITES.

An objection might be raised to this scheme in that Astræiform colonies are the simplest kind possible, involving mere budding round the rim. How is it then that the Perforata only evolved such colonies as a secondary process, viz. from the fixation of rudimentary, immature skeletons, when, in most other groups, it was probably the very first kind of colony to be formed? The answer is simple. The true perforate wall only arose when the epitheca was flattened out, and this was brought about by the septa rising high enough to form a secondary theca above the rim of the primitive epithecal cup.* Tall, conical calicles, such as those which necessarily result from budding above the base, could not form Astræiform colonies. In order to produce them, therefore, the typical perforate calicle, with its tall septal theca, had to be reduced in height, and this was brought about in the way described.

There are a few other perforate genera besides those above mentioned whose positions have been studied in connection with this genus. The important tertiary fossil *Araeacis*, which Milne-Edwards and Haime placed among their Madreporaria Aporosa, shows no fundamental difference in structure from the recent Madreporid *Astræopora*.

Actinacis D'Orb. is a cretaceous and early tertiary representative of the Madreporaria perforata of unknown affinities. Reuss described three lobate branching forms of which the surfaces were well preserved. These are so remarkable that one hesitates before endeavouring to assign the genus any definite place. There is in the National Museum a small collection of early tertiary forms from Kressenberg in Bavaria, the sections of which seem to form a series connecting the genus with *Goniopora*. But more evidence is necessary than that based simply upon sections which are of very inferior morphological importance as compared with the character of the surface that one hesitates on this account alone definitely to associate the

* Cf. the series of diagrams, Journ. Linn. Soc., xxvii. (1899) p. 135.

two genera.* Of *Dictyaræa* Reuss, we only know the small thin branched forms found fossil in the early tertiary strata of Java. These again may be true perforates, and might perhaps be regarded as specialised branching forms of the Poritidæ. But the thin walls on the sides of the stems where the Poritidæ usually have especially thickened reticular walls suggest an origin from simpler colonies in which the perforate walls were typically very thin. This is the case in *Alveopora*, from which the other structural details of the genus might also perhaps be deduced.

V. DIAGNOSIS OF THE GENUS.

The *Gonioporæ* are astræiform colonies of perforate corals, that is, of corals whose thecæ are built up purely of septa united by synapticulæ. The original flattened epitheca persists not merely to protect the colony from the substratum, but as an important constituent of the skeleton, being especially prominent at the free edges. The perforate septa typically number twenty-four, and show bilateral symmetry in the septal formula, there being two primaries as directives. On each side of the directive plane, the remaining septa fuse as follows: two quartets, each composed of one secondary fused with one primary, the two tertiaries fusing with the secondary, and one triplet composed of one secondary with its two fused tertiaries (see the diagram, p. 21). The points where the fusions take place frequently rise as knobs and form the pali which are thus typically six in number, viz. three on each side, two large for the quartets, and one small; sometimes the tips of the directives also form small pali, thus making eight. The position of the directives is sometimes indicated in the middle of the calicle by a tubercle which may be flattened in the directive plane. The original septal formula is, however, frequently obscured and at times only traces of it can be recognised. The inner edges of the septa frequently unite to form a columellar tangle. Owing to the porosity of the skeleton, and to the consequent intercommunication between the parts of the colony, the skeleton of the lower lying portions is always much thicker and more solid than that of the upper portions, according to the law which pertains throughout the whole coral system, that the basal portions of the skeleton are invariably the thickest.

VI. (a) DISTRIBUTION IN SPACE.

The exact distribution so far as at present known shows that the genus is now confined entirely to the coral reefs of the Indo-Pacific area. It is recorded from the Pacific not further east than Samoa, although it is doubtful whether this can be its extreme eastern limit. It is fairly abundant round the northern shores of Australia, through the Malay Archipelago into the China Sea, across the Indian Ocean and in the Red Sea.

* Miss Ogilvie ('Die Korallen der Strassburger Schichten,' Palæont. Suppl. II. 1896–97; see also Phil. Trans., clxxxvii. (1897) p. 211) has suggested an association between *Actinacis* and *Turbinaria*, based chiefly upon sections; the slightly exsert rims of the calicles, never found in the Poritidæ, is further morphological evidence in favour of this suggestion, while the fact that cretaceous Turbinarians are known affords some justification, geologically, for associating them together.

No recent forms are known from the Mediterranean or Atlantic. On the other hand, it is found fossilised all over the South European area and on through Egypt, Persia, and Northern India. Its presence in the West Indian strata (Antigua) is doubtful (see p. 153). It was especially richly developed in Austro-Hungary, in the region of the Venetian Alps, on the shores of the Atlantic near Bordeaux, and in the Paris Basin. In this last area it developed a great number of small delicate forms, which had a character of their own, not encountered again in any of the living forms. A summary of the records justifies the provisional suggestion that the genus arose in the Lower Cretaceous of the Crimea and then spread, on the one hand over Southern and Western Europe, and on the other through Egypt and Persia into the Indo-Pacific region where alone it still survives. This suggestion has no other scientific value than as a working hypothesis.

VI. (b) DISTRIBUTION IN TIME.

The oldest known fossil representative of this genus is from the Lower Cretaceous of the Crimea. It occurs also in the Upper Cretaceous of Bohemia. Other finds which were thought to be of the same period are now regarded as possibly intermediate between Secondary and Tertiary (cf. *G. Sind 1*, p. 93). The great bulk of the known extinct forms range from the Lower to the Upper Eocene when the genus flourished all over the seas of Southern Europe. Through the Miocene it dwindles away. *Between that time and the present we have only two records* (see Table II. p. 168). It is doubtful whether the genus is as plentiful anywhere to-day as it was in Southern Europe during the Eocene period. Apart from such specialised groups as that found in the Paris Basin (usually called *Litharæa*), the genus has undergone no striking change. It is possible that there may now be more forms with tall thin walls than before, but this (if the main points contained in Sec. III. are correct) is a secondary specialisation. All discussions of this kind are, however, rendered unsafe owing to the facts that fossils so frequently have no original surfaces preserved and that most of the recent representatives of the genus known to us are shallow-water forms. There is certainly a wealth of forms both from deeper water and from unexplored strata; until we have some knowledge of these we are but feeling our way.

VII. ON THE METHOD ADOPTED OF ARRANGING THE SPECIMENS.

In writing on this genus, Dr. Ortmann mentions the difficulty he experienced in dividing them into "species" owing to the paucity of characters, the chief being "the size and depth of the calicles," and these he found varied in every specimen. The description of the skeleton here given (Sec. III.) based upon examination of the fine collection in the British Museum, shows a considerable number of new and hitherto unknown characters, but the difficulty of dividing them into genetic groups is not removed.

The aim of all comprehensive systematic work should be to try and build up a natural system. The first requisite is to analyse the known forms in order that the primitive form from which they can be deduced can be approximately described. There can be no natural classification without this as a starting point. So far I feel some confidence in having

succeeded, for the primitive form both of the calicle and of the colony can be fairly easily reconstructed, as has been already described (see Sec. III.). Certainty, however, is out of the question. Hence any system which is built upon this primitive form would partake of that element of uncertainty, and should be only hypothetically constructed. It should not be given to the world as a definitive classification. This is not all. The discovery of the primitive form and even the recognition of the various kinds of modification which have given rise to all the known descendants of that primitive form, are easy tasks compared with that of arranging these descendants into genetic groups. Granted that the primitive form may stand more or less accurately revealed by a simple process of comparison—that is, when enough specimens are brought into line—still the laws under which that form varied, and hence the interrelationships of the resulting variations, remain hidden from us. The usual plan of assuming that degrees of genetic relationship run parallel with closeness of resemblance will not work among the corals. With highly complicated organisms it is more justifiable because, the larger the number of characters, the less is the probability of close resemblance being due to anything but close blood relationship. But even in these cases, we begin to tread uncertain ground as soon as we come to the finer subdivisions based on one or two minor variations. In the more primitive corals the organisation is simple, and all the variations on the ground or generic type seem to be of minor importance and extremely unstable.

As stated above, we are merely in a position of feeling our way; the data for grouping the forms into "species" are not yet forthcoming. Nor can we even group them morphologically with any feeling of certainty. In order to make a satisfactory morphological classification we have to decide which are the primary and which are the secondary characters. In former volumes, although the word "species" was retained, the classification was admittedly purely morphological, and it was assumed that the growth-form was the chief character. But Mr. Pace tells me that the growth-form of *Turbinaria* depends largely upon the nature of the substratum.* The primitive cup-form can only survive in clear water free from sand and mud. And in the genus which we are now describing, the analysis of the growth-forms given above (Sec. III.) shows that they have some intimate dependence upon the form of the central calicles. But we do not yet know whether the growth-form fashions the calicles or the calicles fashion the growth-form. It is certain that they must profoundly influence one another. But until we know, we are unable to give the first rank to either of them. And even if we were to make a plunge and fix upon one of these two as the leading taxonomic character, its subdivisions would run into one another and must inevitably be artificial. The attempt, then, to divide the specimens into an ideal classification either genetic or morphological has to be postponed until the data are available. And here let me say that it has been maintained † that we should have a better chance of success in our attempts to form "species" in corals if we studied the soft parts. In the first place, we can only study what we have got, viz. the skeletons, and in the second place

* See Journ. Linn. Soc., xxviii. (1901) p. 358.

† Mr. J. Stanley Gardiner, in his reply to my 'Unit of Classification,' Proc. Camb. Phil. Soc., xi. (1902) p. 423.

the chance that the soft parts would greatly help is remote; undoubtedly they will have to be studied before we can finally group the corals into species, and this is a further reason for not making that attempt without the knowledge it is hoped they will yield. But at first their study will merely add to the number of minute variations shading off into one another which make the grouping into species so difficult. The soft parts could only reveal to us the limits of species if they were themselves specifically very stable. We have no reason to believe that this is the case.

Under these circumstances—that is, in the absence of all the necessary data for genetic groups—it became necessary to find some *principle of arrangement* which would embody the results of our researches; unless we can do so we are condemned to give a mere haphazard unconnected list of descriptions. The method chosen is that which expresses the only certain data which we possess. The specimens are arranged according to their localities. This, fortunately, is not only extremely simple, but all the facts can be given in such a way as to be constantly accessible, and new facts can be added without having to make any rearrangement. It is important to note that Dr. Günther, in coping with the similar difficulties in his Catalogue of the Salmonidæ, found himself compelled to bring the geographical data into special prominence.

A most important advantage, further, is in the simple character of the designation which this arrangement suggests. At first sight, the simple geographical name may be less euphonious than the customary fanciful name. But it avoids all the disadvantages of such names and hence will, in the long run, be far more useful. The most serious practical disadvantage of the ordinary fanciful name, whether intended to designate a specific group or a mere type of structure, is its tendency to become a snare. It is a snare not only to the bad, but to the careful worker. It is applied quite recklessly by the former, and in desperation by the latter, who instinctively hesitates to give a new name and yet has not sufficient data to allow of a decision as to which so-called "species" his specimen belongs. As far as my experience goes, the records of the different coral genera are in hopeless confusion; the same name has been given to scores of entirely different variations.* Hence, if the object of our published treatises is to build up an accurate knowledge of the genera we describe, we must first of all have a method of designation which will minimise this confusion and allow every apparently distinct form to be recorded in a way which makes identification easy. This is the case with the geographical designation. With this method, the museum official may, in the future, leave the

* A union of great numbers of varying forms may sometimes be deliberate on the part of a conscientious worker, simply because it appears impossible to disentangle the bewildering number of apparently minute intergrading variations. Compare the way my friend Mr. Wayland Vaughan has dealt with the West Indian Porites (U.S. Fish Commission Bulletin, 1900, vol. ii.). This will be discussed in the next volume, but in the meantime I would point out that, while forms may be grouped thus roughly for a general survey of a coral fauna, such grouping is not justifiable when making a special study of a genus. In this latter case, if the manifold variations permit themselves to be grouped genetically, well and good, but if not, one has only to describe them and affix some sign or symbol to them for future reference.

close comparison of his specimens with all the known representatives of their respective genera to the experts who have made the several genera their special study. He need simply compare them with those described from the same localities as his specimens, and though possessing no previous special knowledge, he will be able to publish records of all specimens not hitherto known from the several localities without fear of adding to the present prevailing confusion in the coral system. The modern method which compels such a recorder to give a name to any specimen he describes either as a new species or as one already described, must, in the great majority of cases, add to the vast pile of blind guesses through which we have to dig our way towards true knowledge. It must do so, for, in the corals, we rarely possess the data which would justify us in coming to either of those conclusions.

How great is the need for some method of designation which records only incontrovertible facts, quite apart from purely subjective opinions of the individual worker, may be gathered from the following pages. Such names as "*pedunculata*," "*viridis*," "*ramosa*" and "*epithecata*" will be found to have been mere pigeon-holes into which many very different kinds of *Goniopora* have been hidden away. The older the name and the more difficult it is to ascertain what the original specimen it was intended to denote was like, the more frequently has it been used. See also under "*G. Singapore 2 and 3*," p. 80, for an example of the result of "founding a new species" by a naturalist whose work was far above the average.

In arranging the larger geographical groups, Polynesian, Australian, etc., I have made no attempt to define the areas. All that is necessary is to be able to record the locality where each specimen is found. As long as this is made clear, the necessary facts will be readily accessible however one changes the areas. One difficulty of defining these regions is due to the fact that they have not been permanent. The distribution of land and water was obviously very different when the *Gonioporæ*, now found fossil far in the inland of India, Persia, Egypt, and elsewhere, were growing on reefs. The regions are, therefore, purely artificial and used partly to lighten the dead weight of the number of descriptions, and partly to facilitate reference. The real difficulty in this geographical designation is in indicating the locality. It is not practical to give the exact details in a designation to be used for purposes of reference. It is necessary to invent a district name: for example, "*Goniopora Singapore, 1, 2, 3*," etc. designates corals found in the neighbourhood of Singapore; "*Goniopora Paris Basin, 1, 2, 3*," etc. designates fossils found within the geological area known as the Paris Basin. Here we have taken two natural districts of different kinds. In other cases, we have to take political districts: "*Goniopora Gironde 1, 2, 3*," etc. for fossils found round Bordeaux and so on. All that has been aimed at has been to indicate a district which shall include the exact locality. It may be objected that others may decide upon another district name or may break up the district and thus designate the same specimen by a different geographical name. This would of course make reference somewhat more complicated, but it must be remembered that these designations are not the names of species or really the names of anything. They are indications as to the places where specimens occur, and, vary them as you like, they will always lead you to the same locality. *The synonymy, therefore, which may*

arise as districts become more accurately defined, will be comparatively harmless, for it will be visible in the very names themselves.

Time alone can perfect the method of defining the smaller districts.

The different variations distinguishable in any district are numbered: *G. Singapore 1*, *G. Singapore 2*, and so on, and in this form they are quoted. But, when placed formally at the head of the descriptions, the designation is as follows: G. Singapore (6)**1** to G. Singapore (6)**6**; the bracketed figure tells how many different forms of the coral have so far been recorded from the Singapore district.

These improvements in the way of arranging and designating the different forms are, however, only part of the new method adopted. Having described all the forms and being able to refer to them by a symbol which is itself instructive, we can proceed to draw up tables in which the different forms can be grouped morphologically, and the whole genus may be submitted to a comprehensive analysis. If the tables yield but little positive result, it is because the data are still too few. But the whole is arranged in such a way that new forms can always be added and new characters can be utilised without there being any need to turn the contents of this volume upside down; for there are no premature classifications to be discarded, nor species to be "lumped" or "split." We have given primarily, according to our present knowledge, a chart of the genus as it occurs, fossil or living, on the face of the globe, and we have drafted tables for the analysis of the variations and of their distribution. It is a modest beginning, but it is all that the facts warrant.

In most cases the new method can carry on and incorporate earlier records without any difficulty. So long as single forms or a small group of closely similar forms from one and the same locality have been described as a species and figured, it is quite easy to assign it its place in the geographical list of known members of the genus. But when a "species has been established" upon a group of specimens from several different localities, and the description is founded upon them all without any indication as to the locality of the particular specimens figured, the record is of little help for our list. As, however, no facts can be ignored, we *assume* with a note of interrogation that the figures relate to the specimen found at the first locality named. We then record forms as occurring in the other localities mentioned, and refer to the description already given under the first locality. This so far meets the aim of our work, which is to map out the distribution of the genus, but we are unable in these cases to give a reliable account of the structural details. All we can do is to rearrange and lay out the recorded facts on a plan which can be filled in with correct details later on; thus rendering what was practically useless and confusing a more or less valuable addition to our knowledge.

Lastly, in every museum specimens occur which have no recorded locality. On account of their morphological interest they cannot be ignored, least of all in a work like this which is not only a monograph of a genus, but also a catalogue of its representatives preserved in the National Museum. Seven specimens from unknown localities are recorded at the end of the volume, and a method of designation has been adopted which uses letters as substitutes for their unknown geographical names. [See prefatory note to Group XIV. p. 156.]

GEOGRAPHICAL ARRANGEMENT OF THE FORMS.

Group I.—POLYNESIA.

Containing descriptions or records of Goniopora from—New Guinea (1–2); *New Ireland* (1); *Solomon Islands* (1–4); *Queen Charlotte Islands* (1); *Loyalty Islands* (1); *Fiji Islands* (1); *Tonga Islands* (1–3); *Samoa* (1).

1. Goniopora New Guinea (2)1.

[Bay of Doreh, N.W. corner of Great Geelvink Bay, coll. Voyage de 'l'Astrolabe'; ? Paris Museum.]

Goniopora pedunculata, Quoy and Gaimard, Voyage de 'l'Astrolabe,' iv. p. 218; Atlas, Zoophytes, pl. 16, figs. 9–11.

Description (from original text and figures).—The single specimen of corallum roughly hemispherical, about the size of the fist, with a narrowing base covered with bands of pellicular epitheca.

The calicles are crowded, 2 mm. in diameter, polygonal, tending to become hexagonal [shown nearly square in the magnified drawing]. The walls are vertical, unequally denticulate, granulated and rough. The septal apparatus irregular. The interior of the stock "areolar," and showing a sort of "confused crystallisation."

The polyps are a beautiful yellowish-green; extend 4–6 mm. above the calicles.

Only one specimen of this coral was found and figured by the authors. But there are three specimens in the Paris Museum of a coral labelled *G. pedunculata*, and the one numbered 175*b* is apparently that which Milne-Edwards and Haime described. But it is hardly the coral described and figured by the original authors. It is flatter at the top, and has not anything like so deep a base as that figured by Quoy and Gaimard; nor are the edges of the living growth covered by a pellicular epitheca spreading apparently evenly up the sides, but roll under round the base. Further, this specimen has a great number of large double calicles, none of which are shown in the original figure of Quoy and Gaimard, although they are a striking feature, and specially mentioned by Milne-Edwards and Haime; they are described as being 4–5 mm. in diameter, whereas, if this is the specimen referred to, they are only 3–3·5 mm. in diameter. They also show clear traces of a fourth cycle of septa, which Milne-Edwards and Haime said was rarely the case. The specimen can hardly be called "hemispherical" (Q. and G.) nor does it suggest the term "sub-lobate" of M.-E. and H.

The chief characteristic of these Paris corals is their neatly circular calicles, like cylindrical punctures, very unlike what one would have gathered from the original figures of Quoy and Gaimard, one of which represents a square calicle. They are 2–2·5 mm. across; the walls are built of very thick nodulated trabeculæ, in single zigzag or double rows. The septa are rows of thick, short, sharp teeth, very broadly set upon the wall, and gradually lengthening deep down in the fossa, where they felt and fuse together to form an open columellar tangle. These points of difference, coupled with the facts—(1) that there was only one specimen of the original, whereas Milne-Edwards and Haime apparently had three; (2) that Milne-Edwards speaks of a vertical section, whereas the original was a single complete stock; and (3) that Milne-Edwards merely says from "New Guinea," whereas the authors give a very definite locality—make it fairly clear that the original type was not available when the great French naturalists were working out their coral system.

We shall have then to wait till new specimens are brought from the same spot before we really know what the "*Goniopora pedunculata*" of Quoy and Gaimard was really like. It is true that the name has been given several times by different authors to very different members of the genus, see *G. Solomon Islands 4*, p. 41, *G. Great Barrier Reef 9*, p. 55, and *G. Philippines 4*, p. 70, and the remarks made under those headings.

If the three specimens in the Paris Museum, said to be from New Guinea, are not the same coral as the original "*G. pedunculata*," they ought to be described as a third form from this locality, and the representatives of the genus known from New Guinea will be three instead of two, as here recorded.

2. Goniopora New Guinea (2)2.

[Exact locality not given; Paris Museum.]

Goniopora viridis (*partim*), M.-E. and H., Ann. Sci. Nat. (3) xvi. (1851) p. 40.

Description.—A fragment of a steeply convex [? columnar] mass, the lower parts being covered by an epithecal film.

The calicles are very deep, polygonal, funnel-shaped at the top, shallower and cylindrical at the sides. Walls very open and membranous, the vertical trabeculæ being joined by very perforate membranes. The top edges ragged and very friable. The septa are pronounced, long, close rows of spines, not large at the margin, but rapidly lengthening, until at a certain point the lengthening ceases, and the septal rows descend straight to the bottom of the fossa, where the spines meet and form a columellar tangle, some of the septal spines appearing to fork. In the lateral calicles the columella becomes a rather solid nodulated reticulum.

This description is taken from MS. notes made three years ago upon the specimen No. 178*a* in the Paris Museum. It was quite different from the coral called by Quoy and Gaimard "*Astræa viridis*," with which Milne-Edwards united it as together forming his "*Goniopora viridis*" (see *G. Queen Charlotte Islands*, p. 41); his remark that it resembles *G. lobata* is also there commented upon.

No. 178*a* in Paris Museum.

3. Goniopora New Ireland (1)1.

[Holzhafen, opp. Sandwich Island, coll. German Corvette 'Gazelle'; Berlin Museum.]

"*Goniopora columna* Dana," Studer, MB. Akad. Berlin (1878) p. 524.

Description.—Corallum columnar, 25–30 cm. high, "upper part" alone living.

Calicles not over 3 mm.

Polyps pale violet, very extensible, and unable to retract fully into the calicles.

Said to be beautiful corals growing abundantly in shallow water on dead Astræids. Professor Studer compared them with Ehrenberg's "*Astræa* (= *Goniopora*) *planulata*" from the Red Sea (see p. 100), but the calicles of this latter coral were 4 mm. across.

4. Goniopora Solomon Islands (4)1. (Pl. I. fig. 1; Pl. XI. fig. 1.)

[Balalai Island, Shortland Island, Solomon Islands, coll. Dr. Guppy; British Museum.]

Description.—Corallum forms tall slender clusters of branches running straight up side by side, 30 cm. high. The stem is at first thin, nearly round, 2 cm. diameter, very gradually thickens to 3 cm.; when about 15 cm. high, the top divides into 2 or 3 stems, which however do not diverge; some of them die down after growing 1–2 cm. The dividing tips are blunt and rounded. The living layer is about 4 cm. deep, and the dead part is covered by a thin pellicular epitheca which is either not continuous or else easily dissolved off. A cluster 30 cm. high may consist of only three principal prongs, the rest having died down when quite short.

The calicles at the growing tips of the branches where the texture is loose and reticular differ greatly from those at the sides. The largest are 3 mm. across, angular, opening in a light friable reticulum which would be purely lamellate, but for the fact that the lamellæ are so perforated as to make the immediate surface nearly filamentous; they are usually shallow. The walls are very irregular and fenestrated, and consist either of a single ring of trabeculæ irregularly joined together, i. e. not continuously or regularly zigzag, or else of a jagged reticulum. The septa are represented by short points, until about 1 mm. below the surface when they run out as perforate, irregularly curved plates to join a large open reticular columella. In the larger calicles, traces of the typical formula can be found; but, as a rule, they are all too irregular. A group of pali with jagged or frosted points rises conspicuously almost to the height of the wall. They are quite irregular in number and order. The interseptal loculi are irregular.

About 1·5 cm. below the growing tips, the surface texture rapidly changes from a thin friable and open reticulum into a solid skeleton, built up apparently of smooth, round, closely packed granules fused together (see Pl. I. fig. 1). The columella gradually solidifies; in doing so it passes through a star-shaped phase in which the radial symmetry of the calicle is best seen. In some the centre remains open, in others it closes; it eventually becomes a smooth

solid floor with a few knobs rising from its surface; the interseptal loculi are reduced to pores. The walls which descend straight down about 1 mm. on to the solid floor show hardly any traces of radial septa on their rough granular sides. The calicles are now mostly round and very shallow.

The special points in this coral are: (1) the tall erect stems; (2) the fact that very few of the dividing points survive; (3) the short extent of the living layer; (4) the shallowness of the calicles, even at the growing tips; (5) the rapid solidifying of the skeleton; (6) the early irregularity and gradual obscuration of the radial symmetry which is at last confined to the columella.

There are three specimens of this coral, one cluster and two isolated branches. They had been named *Rhodaræa lagrencii*, by Mr. Ridley, because of the slight resemblance they bear to other specimens, *G. Singapore 1*, which had been so named by Brüggemann (see p. 79). Not only do these two corals differ considerably in the size or character of the calicles (cf. Pl. V. fig. 9), but also in the method of growth (cf. fig. 1, Pl. I. with fig. 12, Pl. XII.) and in the extent of the living layer.

a. Shows the original brown colour.	Zool. Dept. 84. 11. 21. 34.
b. Part of *a*.	Zool. Dept. 84. 11. 21. 34.
c. Bleached.	Zool. Dept. 84. 11. 21. 35.

5. Goniopora Solomon Islands $_{(4)}$2. (Pl. I. fig. 2; Pl. XI. fig. 2.)

[Shortland Island, Solomon Islands, coll. Dr. Guppy; British Museum.]

Description.—Corallum a smooth mass, with irregular oval outline and flattened top; narrow edges, supported by epitheca, creep round a short way under the mass, as far as the large base of attachment.

Calicles neatly circular, as if punctured into the surface as so many cylindrical pits; uniform in size, 2 to 2·5 mm. in diameter; with small buds in the angles. Walls strikingly uniform in thickness, and to the naked eye stout and solid. Seen with the glass the edge of the wall is a uniformly coarse granular reticulum, very porous, thin, and tending to have a sharp upper edge on the top of the corallum, but at the sides thick, flat-topped, and even reticular, often striated transversely by septal edges.

Round the margin within the fossa the 24 septa appear in the uppermost calicles as faint rows of fine points, but in the thicker lateral calicles these points are pronounced knobs, striating the wall. Six of these septa shoot suddenly out from the wall about 1·5 mm. below the edge, and send up flattened paliform processes which rise to within 1 mm. of the aperture, and often much higher. These unite with irregular tissue which rises up in the centre, and form together the columellar tangle. The tertiaries, which remain quite rudimentary, tend to bend round irregularly to fuse with these pali-bearing septa. In the lateral calicles the pali thicken to granular knobs. The interseptal loculi are very conspicuous, and while the radial symmetry is shown in the topmost calicles only by the six-rayed rosettes

rising in the cylindrical calicular pits, in these lateral calicles it is conspicuous both on account of this rosette and of the mural ring of 24 teeth (septa).

In section of the base the coral is very solid, the reticulum being coarse and apparently composed both of very thin and very thick threads; tabulæ can be seen round the edges of the base, towards which the calicles radiate.

This coral has the same general type of calicle as Mr. Quelch's 'Challenger' type, called by him *G. tenuidens* (see *G. Molluccas 1*, p. 65). They resemble one another (1) in having the same circular calicles as if punctured into the surface; (2) in having a similar coarse reticulum along the top edges of the walls; and (3) in their prominent lamellate pali.

The same general type of structure is also seen in *G. Celebes 1* and *G. North-West Australia 1*, etc., see Table III. But in all cases their differences are very great, and their scattered distribution hardly allows us to group them under one heading.

a. Zool. Dept. 84. 11. 21. 27.

6. **Goniopora Solomon Islands** $_{(4)}$**3**. (Pl. I. fig. 3; and Pl. XI. fig. 3.)

[Shortland Island, Solomon Islands, col. Dr. Guppy; British Museum.]

Description.—Corallum forms smooth oval masses with flattened top and with very slight attachment. The edges creep a short way under. A stout epitheca appears under them.

Calicles polygonal, large (4–5 mm.), open and shallow, except at edges which are growing over dead surfaces on the top of the stock. The walls hardly rise above the columella; they are very uniform in height (1 mm.) and in thickness (1 mm.), and are built up of a coarse, rather close reticulum, with an irregular median ridge. The 24 septa project as rows of two or three short knobs down the walls, often a little swollen at the tips. All three cycles eventually reach the columella. The interseptal loculi are open and conspicuous, and the columella is a large convex mass of coarse reticulum, its horizontal flakes giving it an appearance of solidity. The jagged irregular paliform granules show their origin from the points where the septa meet by being often V-shaped. Their grouping, however, is very irregular, and the typical formula difficult to make out. In the denser, more shallow calicles at the sides, these paliform knobs fuse together into solid triangular scales, and are then visibly the fused ends of groups of septa, 3–4 to each scale; or else the large, solid, almost flat columella shows ridges corresponding not only with the primaries, but with the secondaries, and even some of the tertiaries.

The single specimen of this coral, which is remarkable on account of the great size and uniform shallowness of its calicles, is interesting in its apparent method of growth. Its form is irregularly globular, and looks as if a fresh layer of coral were spreading over the whole mass from one end, and that this layer, even though incomplete, had itself already begun to die down in its older parts. This at first sight suggests that the whole coral was built up by alternate waves of fresh growth, oscillating from end to end. And this view receives some

support from the almost total absence of intercalicular budding and the shallowness of the calicles, points which are inconsistent with rapid continuous growth in thickness, but just what one would expect of a thin, explanate, incrusting stock. It has been suggested to me by Mr. Pace that such a growth might be due to periodical changes in the direction of the current. One side is killed, perhaps by the silting up of mud or sand, while the other thrives. When the current turns, the thriving part dies down, and the former dead part is grown over by a fresh layer.

The points to be noted in this coral are (1) the very large shallow calicles; (2) the low, rounded reticular walls, with no trace of septa running across them; (3) the large prominent columella with its irregular group of paliform granules; (4) the conspicuous ring of 24 narrow interseptal loculi; (5) the scarcity of the intercalicular budding; (6) the coarseness of the whole of the surface texture.

a. Zool. Dept. 84. 11. 21. 26.

7. Goniopora Solomon Islands (4)4.

[Bougainville Island, coll. German Corvette 'Gazelle'; Berlin Museum.]

"*Goniopora pedunculata*, Q. & G.," Studer, M.B. Akad. Berlin (1878) p. 524.

There is, unfortunately, no description of this coral. Prof. Studer, in identifying it with Quoy and Gaimard's coral from Great Geelvink Bay (see *G. New Guinea 1*), was doubtless guided by apparent similarity of growth-form. As stated above, it appears to me that we shall have to collect on the same spot in Great Geelvink Bay before we really know what the original "*G. pedunculata*" was. This same remark applies also to Brüggemann's and Mr. Quelch's identifications. See *G. Great Barrier Reef 9* and *G. Philippines 4*, pp. 55 and 70.

8. Goniopora Queen Charlotte Islands (1)1.

[Vanikoro, Queen Charlotte Islands,* coll. Voyage de 'l'Astrolabe'; Paris Museum.]

Astræa viridis, Q. & G., Voyage de 'l'Astrolabe,' Zooph., iv. (1834) p. 204, pl. 16, figs. 1–3.
Astroitis viridis, Dana, Zooph. (1848), p. 406.
Goniopora viridis (*partim*), M.-E. & H., Ann. des Sci. Nat. (3°) xvi. (1851) p. 40.

Description.—Corallum round or oval, like the swollen end of a short thick column, about the size of the fist. The calicles are large, "about 4 mm., polygonal, deep, conical, with vertical, very rough walls." The septa are "equal, denticulate," and "do not reach the base of the fossa" (the figure of the longitudinal section shows them meeting across the fossa).

The polyps project about 12 mm., are cylindrical, with both longitudinal and transverse furrows, protuberant mouth with "numerous" tentacles; in the original figure there are 48 of the latter, alternately larger and smaller; in the text they are said to be "somewhat irregular." The polyps are a bluish-grey colour, with green tentacles, and they can retract completely into their calicles.

* I prefer the old name, there being many Santa Cruz Islands.

The value of Milne-Edwards' description of "*Goniopora viridis*" is seriously impaired by the fact that he joined the specimen from Vanikoro with another from New Guinea, and gave a joint description! They are, fortunately, both preserved in the Paris Museum, Nos. 178*b* and 178*a* respectively.* The former of these is the original of Quoy and Gaimard. It looks like the swelling top of a columnar Goniopora sawn off. At the growing top it is very friable and ragged, and suggests an approach to the sheaf method of growth (see Introduction, p. 26). The calicles are here rather deep funnel-shaped. At the sides they are shallow, and from 4–4·5 mm. across. The characters of the septa are unique: they are very perforated and lattice-like, and their edges run out into ragged filaments, those forming the uppermost layer of the columellar tangle being specially fine and delicate. In the original figure of a vertical section of a calicle, the septa are shown as if meeting and forming a continuous perforated plate right across the fossa. This is not correct. The division between two opposite septal edges remains distinct. I made no note as to there being more than 24 septa (cf. the fact that 48 tentacles are figured by Quoy and Gaimard).

Milne-Edwards called attention to the resemblance between this coral and "*G. lobata*." I find that the resemblance between this coral and the Red Sea form *G. Red Sea 1*, which Dr. Klunzinger identified with *G. lobata*, is recorded in my Paris notes.

Type specimen in the Paris Museum, No. 178*b*.

9. **Goniopora Loyalty Islands (1).** (Pl. I. fig. 4; Pl. XI. fig. 4.)

[Sandal Bay, Lifu, Loyalty Islands, coll. Willey; Cambridge University Museum.]

Description.—The living layer forms a long, narrow, rather smooth, bolster-like ridge, the growth dying away on one side, but apparently rolling over with a thick drooping edge on the other. A thick, chalky pellicular epitheca, covering the dying surface, sinks deeply into the calicles.

The calicles angular, average about 3 mm. in diameter, very deep, 4–5 mm., and conical; deep even at the sides, where the colony is dying down. Walls on the top sharp,—thicker and striated by septa at the sides,—very steep, stout, fenestrated. The sharper margins very slightly and coarsely toothed by the tops of the 24 narrow septal ridges, which are slightly serrated, or bluntly granulated, and only just project from the wall. The tertiaries mostly die away before reaching the base of the fossa, while the primaries become slightly more prominent, and eventually curve outwards to join a columellar tangle, and may form a 6-rayed star upon the columella. The secondaries also join the columella, and, in sections, one finds 12 clear, rounded, interseptal loculi, with slight traces of tertiaries which unite almost immediately with the secondaries. Paliform granules not specially conspicuous. Young calicles appear both in the angles and round the growing edge as small, deep conical pits, sharply defined, not as irregular breaks in any reticulum, except when very minute.

The corallum, though heavy and solid, owing to the thickness of the skeletal elements, has a somewhat open texture, owing to the size of the interseptal loculi.

* For the description of 178*a*, see *G. New Guinea 2*, p. 37.

The single specimen is 11 cm. long, 4–5 cm. across, and 2–3 cm. deep. It is a long narrow ridge, sawn off just below the last living colony, on the one side of which the living layer is rolling over, while on the other a continuous pellicular epitheca, coming up from the nearly vertical side, is covering over the dying calicles. This pellicle is not smooth and shining, but granular and chalky. It is, consequently, difficult to designate this method of growth—the rolling edge suggests what we find in the "pulvinate" growth-forms. (Cf. also *G. Red Sea 6*, Pl. XIII. fig. 13.)

The chief characteristic of this specimen lies in the great depth of the calicles. Even the lateral calicles, though shallower, retain their special characters almost more marked than any other known Goniopore—that is, their tendency to return to the primitive type (see Introduction, p. 22), though apparent, does not go very far. It shows itself chiefly in the appearance of a group of paliform granules on the floor of the still deep calicle. This is also characteristic of the pulvinate method of growth, and is readily understood by reference to the diagram C in the Introduction, p. 24. Owing to the number of deep buds the calicles on the top appear to be of all sizes, irregular in shape, slightly angular, and with strong-looking walls, the top edges of which are not uniformly level over the whole surface.

For the list of deep-calicled Goniopores, see Table IV. B (*b*) *a*, p. 179.

The rose-pink colour of the dead stock is found also in the form *G. Great Barrier Reef 11*, which has also somewhat similar calicles, though not so deep. The growth-form also is different.

10. Goniopora Fiji Islands (1).

[Wilkes Expedition.]

"*Goniopora columna*," Dana, Zoophytes (1848), p. 570, pl. 56, figs. 5, 5*a*, 5*b*.

Description.—Corallum forms compressed, cylindrical, sub-clavate columns 25–50 cm. high, 5–10 cm. thick, summits rounded, furcately subdividing above, alive for 5–7 cm.

Calicles angular, "excavate," 3 mm. across; margin sharp, granular. Lateral calicles very shallow, without distinct septa ("lamellæ").

Corallum very porous.

This is in substance Dana's original description. From the figure it would appear as if the epitheca formed a continuous pellicle over the dead portion, as no traces of the corroded calicles are shown. Usually the calicles show through. There are "no distinct" septa, and in the figure (5*b*) septa are merely indicated round the edges of a few calicles. Dana's distinct statement precludes us from supposing that the specimen had not been cleaned. It may be that, as in the columnar form *G. Singapore 2* (see Pl. XII. fig. 13), the skeleton was melted down into a granular reticulum in which the radial symmetry had become obscured (Pl. VI. figs. 1 and 2).

The polyps are described as being cylindrical, salient, 4–6 mm.; of a pale lilac colour, and with 18–24 tentacles.

This cylindrical growth-form is not rare (see Table III. p. 169). But in Dana's coral there were some peculiarities; the columns forked, and were very tall, up to 2 feet; then again the

small size, and irregular angular outline of the calicles; and most important of all the obscuration of the septa.

These points should lead to its re-discovery. See the table referred to for other known cylindrical Goniopores, one of which (see *G. New Ireland 1*) Professor Studer* proposed to identify with Dana's coral.

The only columnar Goniopore with obscured radial symmetry in the National Collection is *G. Singapore 2*, but in this coral the lateral calicles gradually recover the typical symmetry. Cf. Pl. VI. figs. 1 and 2.

11. Goniopora Tonga Islands (3)1. (Pl. I. fig. 5; Pl. XI. fig. 5.)

[Tongatabu, coll. J. J. Lister; British Museum.]

Description.—Corallum forms thick cushion-shaped masses with bulging sides, which develop as excrescences one upon the other, the basal being the smallest. A sharp, often free edge, supported by epitheca, is traceable round each fresh growth.

The calicles are very uniform in appearance, 3–4 mm., polygonal, open, 2–3 mm. deep. Walls very uniform, thin, perforated and very zigzag along the edges, the narrow tops of the radial septa of adjacent calicles alternating with one another. The synapticular bars appear below the edges, which are thus raggedly denticulate. The 24 narrow septa descend straight down the wall as regularly denticulate ridges, each ridge being further characterised by a still finer denticulation (or frosting), only seen under a pocket lens. The two first cycles of septa join the large coarsely reticular columella without becoming very prominent as septa, while the tertiaries tend to bend round to fuse with the secondaries.

The typical fusions take place and can be seen even with the naked eye, but the pali are hardly traceable except as slightly larger curlings and frostings of the surface of the large rather flaky columellar tangle; they are most conspicuous in the shallower lateral calicles.

The interseptal loculi are very irregular in size and are not conspicuous.

There are three varieties of Goniopores from Tongatabu in the National Collection, the one here described, and the two which are classed together under the next heading. They all agree in growth-form. This seems to consist of great rounded cushion-shaped excrescences, starting on the tops of previous rounded masses, which may or may not have rolled over. In the one now described the stock shows a nearly regular succession of expanding cushions (cf. the pulvinate method of growth, diagram C, fig. 2, p. 24, Introduction).

The calicles in all these are about the same size, but there the likeness really ends, for in this coral they are very regular, with septa not conspicuously laminate (see Pl. I. fig. 5), with no signs of rapid growth, and with a columellar tangle which in the lateral calicles becomes large, conspicuous, and almost convex. Still it is possible that very rapid growth might transform it into the next type.

a. (With a young colony attached). Zool. Dept. 1902. 9. 9. 1.
On the original label is a note, "Polyps much extended (·75 inch), brown madder-colour."

* MB. Akad. Berlin, 1878, p. 537.

12. **Goniopora Tonga Islands** $_{(3)}$**2**. (Pl. I. fig. 6; Pl. XI. fig. 6.)

[Tongatabu, coll. J. J. Lister; British Museum.]

Description.—Corallum appears to be built up of smooth cushion-shaped masses capping similar but smaller growths. The cushions are large and thick.

Calicles vary greatly in size in different parts of the same mass, from 3·5 mm. to 2·5 mm. and about 2 mm. deep. The walls over all the upper parts are thin, friable, incomplete, and very perforate, the thin synapticulæ running in a pronounced zigzag. The 24 septa rise as thin pointed lamellæ, often free, that is, not joined by synapticulæ, and making the surface look bristly. The primaries and secondaries alone slope inwards to the columellar tangle, the tertiaries remain rudimentary. Denticulations of their inner edges bend up as tall, delicate pali in the uppermost calicles. But in the lateral calicles the pali form a clear ring or oval of six, with frequently a central fossa. The interseptal loculi are large, owing to the tertiaries remaining rudimentary.

Very delicate tabulæ are numerous and the corallum is light and porous; the transverse section is composed of radial groups of lamellate septa joined by inconspicuous synapticulæ. The ragged inner edges of the septa are seen to interlace to form the columellar tangle.

We have here clear indications of an approach to the sheaf-method of growth, combined with the pulvinate method of growth of the last form, the successive cushions of which seem to grow slowly and are trabeculate in structure. In this coral they grow very fast, and the lamellate septa shoot up like spikes all over the surface, making a considerable difference in the aspect of the calicles (cf. Pl. I. figs. 5 and 6) and in the general characters of the stock. Yet it is obvious that the differences might be referred to rapidity of growth due to some accident of the environment.

Taken together the forms show a most instructive transition between the ordinary convex growth of the pulvinate type, and the expanding column of the typical sheaf formation (cf. figs. C and E, Introduction, p. 24).

There are five specimens and fragments included under this heading. Four are fragments of probably one large stock (*a*); three of these actually fit together, while the fourth contains fragments of the same madrepore overgrown by the others. The other specimen *b* (see Pl. XI. fig. 6) is somewhat different from (*a*), and in the direction of the coral last described—and as there stated the differences may be due to variations in the rate of growth. The corals *a* and *b* agree (1) in the character of the calicles, (2) in the curious crimped or wrinkled walls formed of the tips of the radial septa joined by very thin, often zigzag synapticular bars, (3) in the number of the septa, and (4) in the group of prominent pali frequently surrounding a small central fossa. They differ chiefly in their vertical sections. The one (*a*) which appears to have grown most rapidly and has incorporated branches of madrepores, is in section little more than a sheaf of narrow lamellate septa. Further, as stated in the description, the horizontal section shows little more than star-shaped groups of lamellate septa, the thecal tissue being reduced to a thin often zigzag thread.

In the other stock (*b*), while the appearance of the horizontal section agrees fairly closely with that just described, the vertical section has a very different aspect. It appears to consist simply of bundles of trabeculæ joined by horizontal bars, it being difficult at first sight to say which trabeculæ are mural and which septal. Examination of the transverse section shows a tendency in the septa to be lamellate, although most of them remain trabecular, and also that the mural trabeculæ are the thicker. We cannot at present see why difference in rate of growth should cause such differences of structure and texture.

But two facts show that this is the chief cause: (1) on the slower growing incrusting stock *b* the calicles on the highest ridge, and therefore those which are in most rapid growth, approximate most to the calicles in the other stock *a*; (2) on the stock with lamellate septa the topmost calicles are much smaller, very crowded, and with frequently incomplete walls, which are well-known signs of very rapid growth and multiplication.

In all the specimens, while the skeletal elements are on the higher parts of the stock smooth, they are rough and frosted in the lateral calicles.

a (four fragments (a_1, a_2, a_3, a_4) of a rapidly growing stock). Zool. Dept. 91. 3. 6. 96.
b (slower growing stock). „ „ 91. 3. 6. 54.

Compare the description of the next coral.

13. Goniopora Tonga Islands (3)3. (Pl. I. fig. 7; Pl. XI. fig. 7.)

[Tongatabu, coll. J. J. Lister; British Museum.]

? *Goniopora parvistella*, Ortmann, Zool. Jahrb., iii. (Syst.) (1888) p. 158, pl. vi. fig. 3.

Description.—Corallum massive, like a shallow inverted cone, with the edges of the broad, flat, convex top rounded off. Living layer extends under, but dies down a short distance from the base of attachment.

Calicles small, average 2 mm. on the top, where they are very deep, irregular in shape, and angular. On the under surface the calicles average 2·5 mm., and about 1 mm. deep, angular and largely drawn out of shape. The walls of the uppermost calicles are very ragged and irregular and look thicker than they are, because their most conspicuous elements are the tops of the lamellate septa, whose radial symmetry is obscured in spite of their conspicuous development. These tips of the septa are united together by a single, usually zigzag synapticular wall with only occasional perforations, hence the walls are generally complete along the edge. The septa appear in three cycles at the margin of the walls, but near the columella the number is much smaller. They show no traces of the typical septal formula. For the sizes of the calicles they are thick and lamellate, usually coarsely toothed, a few in each calicle are specially prominent at the margin. The radial symmetry is frequently disturbed by two prominent adjacent septa being parallel to one another. A varying number of septa (6–12), meeting at different angles, form an open axial columellar tangle. On this, incon-

spicuous paliform knobs appear. In sections parallel with the surface the individual calicles are easily traceable by the zigzag lamellate walls separating groups of large irregular interseptal loculi, which appear between some twelve thick, rough, lamellate septa.

We appear to have here almost an extreme form of the sheaf-formation. We have a very rapidly expanding bundle of thick lamellate septa, which rise up in a most conspicuous manner on the top of the walls. This is interesting because of the tendency to the same growth-form seen in specimen *a* of the last type. There we could attribute it to great rapidity of growth, but here nothing of the kind is suggested.

Dr. Ortmann has figured a form which he called "*G. parvistella*," believing that it had the smallest calicles of any known representative of the genus, which was perhaps true at the time, but is no longer so. But, beyond quoting his figure and noting the superficial likeness in the calicles, which however were much shallower, and that the growth-form was a cluster of irregular knobs which but faintly suggest the same expanding cone formation, little further use can be made of his work. Instead of describing a form, he *made a "species"* containing specimens from Tonga and from Samoa, and he unfortunately omitted to say to which his figure referred. (See, however, under next heading.)

The special points in this coral, apart from the sheaf-formation, are the very small calicles, the obscuring of the radial symmetry by the fact that prominent septa often seem to run parallel to one another, the great thickness of the septa, and their conspicuous appearance on the margin of the walls where they are thick, crowded, and laminated.

a. Zool. Dept. 91. 3. 6. 20

14. Goniopora Samoa (a)1. (Pl. I. figs. 8–9; Pl. XI. fig. 8.)

["Probably No. 1285 of the Godeffroy Collection, '*Goniopora* sp., Samoa'"; British Museum.]

? Goniopora parvistella, Ortmann, Zool. Jahrb. iii. (Syst.) (1888) p. 158, pl. vi. fig. 3.

Description.—Corallum forms towering masses (over 20 cm. high), apparently built up by thick incrustations, the surfaces of which rise into club-shaped masses, with rounded tops and sides often flattened by mutual crowding. Too irregular to be called columnar. The lower edges of the growing tops may join across the valleys, obliterating the column-like growths of former periods. An epitheca appears under the edges of the living layers, but the dead faces are not covered by any pellicle.

The calicles (Pl. I. fig. 8 near the top; fig. 9 from a detached fragment of the base) are very variable in size, average 3 mm., polygonal, with many double calicles, everywhere shallow. Walls often hardly traceable, usually low, irregular ridges of half-flaky, half-filamentous reticulum. In the more regular calicles the inner margins of the walls show fine septal points, but there are only faint traces of radial symmetry; thin curling, irregular septal threads soon join a large columellar tangle of the same open flaky reticulum. Above this tangle the septa can be seen to be fusing, especially in the basal calicles, fig. 9, but even there the typical formula is obscured. The interseptal loculi are very irregular, and hardly distinguishable from the round pores in the reticulum. On the summits, and apparently the most rapidly growing parts, the

whole surface is a confused flaky reticulum, in which calicles are mainly discoverable by being faint depressions.

From the large columellar tangle groups of irregular jagged flakes rise to represent a ring of pali. Approximation to the typical six can be seen, and traces of dimorphism * are visible.

There are two specimens, *a* and *b*; one (*b*, fig. 9) is a detached rounded nodule, which may have been free, the greater part covered with a fresh incrustation. It is difficult to describe the growth-form of *a*. It appears to be a development of an explanate-encrusting stock, which has risen into lobes, these swelling and dividing into thick knobs. (See Pl. XI. fig. 8.)

The calicles are all shallow, even on the tops of the knobs, so that the growth-form is not one of those attributable to the lengthening of central calicles (see Introduction, p. 24). But though all the fossæ are shallow, there is no close return, even in the lowest calicles (fig. 9) to the primitive type.

There is considerable superficial resemblance between this coral and *Goniopora Singapore 2*. The columnar growth of the latter is, however, much more conspicuous (see Pl. XII. fig. 13 and p. 80), and the calicles are a trifle smaller (see Pl. II. figs. 1 and 2), otherwise their general appearances are the same. The most fundamental difference lies in the texture of the skeleton, which in the Singapore coral is a close granulated reticulum, but this again is as irregular in its way as is the open flaky reticulum of the coral here described. This resemblance receives additional importance from the fact that the locality of this specimen is not above suspicion.

That true *Gonioporæ* occur at Samoa we gathered from the last heading. It is possible that Dr. Ortmann's *G. parvistella* may be more nearly allied to this than to the last form.

a. Large stock.	Zool. Dept. 1902. 9. 9. 2.
b. A (? free) nodule.	„ „ 1902. 9. 9. 3.

Group II.—AUSTRALIA.

Containing descriptions or records of Gonioporæ from the Great Barrier Reef (1–12); *North-West Australia* (1–6); *and one from "Australia," but with no nearer locality.*

15. Goniopora Great Barrier Reef (12)1. (Pl. II. fig. 1; Pl. XI. fig. 9.)

[Townsville, Great Barrier Reef, coll. Saville-Kent; British Museum.]

Description.—Corallum explanate, with smooth wavy upper surface, while the under surface, lined with wrinkled epitheca which is thrown into deep folds, is irregularly cavernous and hollow. The edges of the stock run out free, and are 2 mm. thick at the margin, which is supported by epitheca, and breaks up into rounded lobes. These marginal lobes bend upwards,

* That is, some calicles have a deep central fossa, absent in the others. See Journ. Linn. Soc., xxvii. (1900) p. 496.

curl round longitudinally, and, as the colony expands, appear to be left behind as blunt knobs on the surface of the stock. The thickness of the colony is very irregular, from 1–1·5 cm.

Calicles 4 mm. in diameter; on the smooth surface open, shallow and subcircular and regular, but on the lobes and knobs drawn out of shape, sharply angular, and often deep and funnel-shaped. The walls are everywhere finely reticular, thick, varying from 1 to 2 mm. where thickest, flat-topped, often with the open shallow indentations of young buds. The 24 septa, with frilled rather than toothed edges, appear on the top of the wall, and remaining very short descend nearly vertically into the calicle, where they grow out to form the typical septal formula, which is sometimes visible to the naked eye. Their fusions result in the usual six paliform prominences on the columella; these prominences are lengthened out radially and are large and very conspicuous; under the lens they are seen to be raised portions of the columellar tangle. The directives also frequently have minute separate paliform granules. Great numbers of delicate tabulate floors begin about 2·5 mm. below the surface.

There are two specimens of this foliate Goniopore, both from the Great Barrier Reef, one (*a*) labelled "Townsville" and the other (*b*), unfortunately, only "Great Barrier Reef." Their method of growth, general thickness, regular character of calicles, walls and epitheca are exactly similar. In specimen (*b*), shown on Pl. XI. fig. 9, we have a free edge, showing the formation of knobs by curling lobes; in (*a*) we have a completed knob rising from a smooth face from which nearly all the free edges have been broken away. The only difference between the two which I can detect is due to the fact that in (*a*) the skeletal elements seemed to be a little finer than in (*b*); this gives a slightly different surface aspect. The septal formula is less clear, and the ring of pali more irregular in (*b*) than in (*a*). Specimen (*a*) has been bleached, but still shows faint traces of both the brown and olive-green colours which occur in (*b*). There can be no doubt whatever that these two corals are intimately related, and, I expect, came from the same locality. This is an example of the explanate growth-form with persistence of the regular primitive type of calicle. Its curling-up edges, leaving knobs on the surface, suggest a similar origin for the branching tufts of *Goniopora Great Barrier Reef 12*, see p. 58.

a. Zool. Dept. 92. 12. 1. 160.
b. „ „ 92. 12. 1. 677.

16. **Goniopora Great Barrier Reef (12)2.** (Pl. II. figs. 2–3; Pl. XI. fig. 10.)

[Palm Islands (almost due north of Townsville), Great Barrier Reef, coll. Saville-Kent; British Museum.]

Description.—Corallum is a thick cockscomb-like ridge with swollen, slightly lobate crest. The living layer above the epitheca varies from 2 to 4 cm. deep. The thickness of the crest is 3 cm. An epithecal film creeps up the sides of the crest in broad irregular strips, strongly wrinkled.

Calicles very irregular in size, up to 2·5 mm., angular and thin walled in the valleys between the lobes, but deep, round, and funnel-shaped, or cylindrical, on the smooth round tops of the lobes (see Pl. II. fig. 2), round and shallow at the sides (see Pl. II. fig. 3). The walls are thin and built of stout palisades between the crowded angular calicles, but thick, round-topped, and reticular between the deep calicles; broad, up to 2 mm., flat and granular, with a faint median furrow between the shallowest lateral calicles. Twenty-four septa striate the thicker walls, rising above them as plates and projecting into the calicle as short sharp points, which descend vertically as straight, sharp, but slight and interrupted ridges into the fossa. The tertiaries soon become rudimentary. The primaries (and ? some of the secondaries) project suddenly as thin delicate plates, from which small knobs, sometimes thin plates or plate-like teeth, arise in the fossa to a variable height, sometimes remaining deep down, to form the pali. In the lateral calicles these become stout frosted granules. In these shallow calicles the flat wall appears solid, its broad top is covered with rows of frosted granules, corresponding to the two sets of septa. The coral is very tough and heavy.

The single specimen, 10 cm. long and 9 cm. high, is interesting because its growth-form is unique in this genus. Its chief structural features are, the slightly exsert septa shown in fig. 2 (Pl. II.), which change into the broad flat wall shown in fig. 3. The median furrow here shown is rare in this genus.

The deep calicles at the top, changing into the primitive type at the sides, show that it owes its massive form and rounded top to the lengthening of the central calicles.

An outgrowth from one of the free edges shows what the early stage of the colony may have been (see fig. 10, Pl. XI.). The centre is raised and the edges are rapidly expanding, with a zone of small buds. This, as stated, is not really a young colony but arose as an outgrowth from the larger stock, and has the free edges of similar outgrowths under it.

a. Zool. Dept. 92. 12. 1. 162.

17. Goniopora Great Barrier Reef (12)3. (Pl. II. fig. 4; Pl. XI. fig. 11.)

[? Exact locality, coll. Saville-Kent; British Museum.]

Description.—Corallum round pear-shaped, enveloping the tops of other corals, which it closely encrusts, the lower edges of the living layer creeping under into all the crevices and open spaces. An epitheca appears under the creeping edges, and sometimes bending up on to them as a pellicular covering.

Calicles neatly rounded like deep cylindrical punctures, variable in size up to about 3·5 mm. across and about 3 mm. deep. Walls vertical, and where thin, i.e. on the top of the stock, very friable and fenestrated, as if built up of rows of jagged trabeculæ very sparsely joined into a zigzag, making the rims ragged and irregularly denticulate. Nearer the sides the walls thicken and the septa show across their tops. They still, however, remain very open and friable, but become more solid still lower down, where indications even of a double row

of septa separated by a median furrow may appear. The 24 septa appear uniformly developed as slight knobs round the margin and descend as inconspicuous ridges into the fossa, only becoming differentiated in its base, where the typical septal formula can be easily seen. Their fusions result in an irregular granular axial tangle, from which long, thin, jagged points tower up as pali, often almost to the aperture of the calicle. In the shallow lateral calicles columella and pali solidify into a large group of 6 smooth coarse glassy grains nearly filling the base, each grain being obviously the point of fusion of either 3 or 4 septa. The 24 interseptal loculi are conspicuous around the columella, but are greatly shortened by the size of the rosette in the shallower calicles.

The calicles figured are from the side about half-way down, where the tall spike-like pali are passing into the coarser granules of the lowest calicles.

The single specimen forms a nearly globular mass which has enveloped the tips of some branches of a *Mussa*. It is nearly 10 cm. in diameter, but rather light owing to the very open character of its skeleton. The upper surface is extremely friable. The lower edges nowhere hang free, but closely adhere, running in between the calicles of the *Mussa*. The specimen closely resembles the *Mad. intersepta* Esper, see below, *Goniopora xg*, p. 160. For a somewhat similar method of growth, by the close investment of projections from the substratum, see *G. Great Barrier Reef 7*, specimen *b*, Pl. XII. fig. 1. The extraordinary friability of the top of the stock, owing to the extreme fenestration of the septa, and the tall jagged spike-like denticulations of the walls, coupled with the method of growth, are the chief features of this coral.

As in the case of *G. Tonga Islands 2*, specimen *a*, we are inclined to ascribe this very porous and friable skeleton to rapid growth. The stock is very light for its size. We may note as a further interesting feature of this coral that the rosette formation is especially conspicuous even in the uppermost calicles, in which it is usually obscured, that is, when the calicles are deep. In the lateral calicles the rosette is by far the most striking structural feature.

a. Zool. Dept. 92. 12. 1. 419.

18. Goniopora Great Barrier Reef $_{(12)}$4. (Pl. II. fig. 5.)

[Exact locality not recorded, coll. W. Saville-Kent; British Museum.]

Description.—Corallum with smooth rounded surface, and with hardly any free edges, the living layer being bulged out all round the specimen, which is unfortunately only a fragment.

Calicles 3·5–4 mm., subpolygonal and deep, 3–3·5 mm. The walls are thin and built of straight rows of stout nodulated trabeculæ, the tips of which appear like grains in single rows along the edges of the walls. The perforations in the wall are fairly regular oval apertures, in vertical series, making the otherwise stout walls a somewhat open lattice-work. The granules forming the edges of the thicker walls of the lateral calicles are large and coarse,

18 to 20 in number. Septal ridges hardly traceable down the walls in the deeper calicles, and as a rule only begin to appear as teeth some way below the surface, excepting in the shallower lateral calicles, where they are visible as ridges right down the walls. The primaries and a few of the secondaries alone become conspicuous. The columella is a very solid tangle of coarse round threads, from the surface of which arise irregular pali which seem plate-like from above, but are often mere radially arranged filaments, forming the typical rosette. These pali are slight in the deep calicles, but become more and more pronounced in the lateral calicles. One palus is often more prominent than the rest, but the septal formula is too obscured to allow us to make out which it is. The texture of the corallum in section is a very coarse filamentous reticulum, in which, however, the thick walls are prominent. Very delicate tabulæ, not numerous, are visible with a pocket lens.

The single specimen had apparently been split in half at some time from the top of its smooth rounded mass to its base, and the living layer had bent down over the edge of the fracture. The growth-form is provisionally placed in the pulvinate group, see Table III. p. 174, and Introduction, pp. 24 and 26. The specimen differs from most of its congeners in the character of the walls, their edges being composed of single rows of granules. It resembles the last specimen in the conspicuousness of the rosette even in the deep uppermost calicles.

a. Zool. Dept. 92. 12. 1. 542.

19. **Goniopora Great Barrier Reef** $_{(12)}$**5.** (Pl. II. fig. 6.)

[? Exact locality, coll. W. Saville-Kent; British Museum.]

Description.—Corallum a smooth laterally compressed ridge, with long oval contour, slightly bulging sides, and smooth rounded crest. Thickness of stock, 3–3·5 cm. Depth of living layer on the sides, 3–4 cm., but dying irregularly upwards without free projecting edges.

Calicles deep circular punctures, variable in size up to 2·5 mm., and 2·5 deep on the higher parts of the crest. Walls very fenestrated with rather ragged edges, variable in thickness but generally thin, with top edges striated by thin bent septal plates conspicuous to the naked eye. No septal points project over the margin, and the wall descends vertically almost entirely devoid of radial ridges (with here and there exceptions). Six symmetrically arranged pali as small points rise high in the calicle near the wall. They are usually thin narrow plates, the bent up teeth of six septa, one or two of another cycle may be developed sufficiently to fuse with them, but the rest, with the tertiaries, remain rudimentary. The interseptal loculi are consequently very large and open. The columellar tangle is light and open. In the vertical section the wall trabeculæ stand out solid and conspicuous as compared with light intracalicular reticulum.

This is only a chip, but it shows the method of growth, somewhat reminding one of the narrow cockscomb-like ridge formed by *G. Great Barrier Reef 2*. The skeletal details can be seen in the fig. 6 (Pl. II.) to be thin and delicate, and in great contrast with those of the preceding figure.

a. Zool. Dept. 1902. 9. 9. 4.

20. **Goniopora Great Barrier Reef (12)6.** (Pl. II. figs. 7, 8; Pl. XI. fig. 12.)

[Albany Passage, Northern End of the Great Barrier Reef, coll. Saville-Kent; British Museum.]

Description.—Corallum a hemispherical mass capping smaller growths of the same. A thick wrinkled epitheca under each of the edges, which in this case were prevented from closely encrusting by the presence of foreign organisms.

Calicles subcircular, about 3 mm. across, from 1–2 mm. deep, with open ragged margins (that is, *not* as if neatly punctured). The walls at the top are smooth thin lattice, with friable denticulate edges; but everywhere tend to thicken into an elegant but rather irregular reticulum (see fig. 7). The septal tips do not striate the top of the wall except in lateral calicles (fig. 8). Occasionally instead of septa a row of meshes is conspicuous on the top of the wall when looked at from above. Septal ridges not usually apparent round the mouth of the calicle except in shallow lateral calicles. The primaries as a row of sharp spines form a conspicuous symmetrical six-rayed star, the teeth turning up to form a compact ring of thin plate-like pali, which in the lateral calicles become very irregular and jagged. Secondaries fairly well developed, sometimes fusing near the centre with the primaries. The tertiaries quite rudimentary, except in the lateral calicles, where traces of the typical formula can be seen in the jagged reticulum formed by the thickened wall and the large columellar tangle.

This is one of the Gonioporas in which the melting down of the skeletal elements to form a reticulum has just gone far enough to retain a radial symmetry underlying a very beautiful irregularity of texture. It belongs to the group with deep calicles and conspicuous rosettes of pali. The youngest growth composing the stock is about 3 cm. in diameter, and is interesting because the *walls* of its calicles as seen in section are hollowed out by an alga, while the intracalicular skeleton has been generally spared. It is not easy to see the reason for this differential action, unless it be that the growing tips of the alga were confined to the extreme top edges of the walls and thus raised above the level of the septa.*

The most recent growth is some 8 cm. in diameter, but seems to have been kept from closely encrusting the earlier growths by the presence of other corals. The rosette of pali in the lateral calicles looks very symmetrical to the naked eye, but under a pocket lens the symmetry disappears. The jagged spiky reticulum is well shown in the figs. 7, 8 (Pl. II.), which represent as usual the upper and lower calicles respectively.

a. Zool. Dept. 92. 12. 1. 149.

21. **Goniopora Great Barrier Reef (12)7.** (Pl. II. fig. 9, and Pl. III. figs. 1, 2; Pl. XII. fig. 1.)

[Warrior Islands, Torres Strait, colls. W. Saville-Kent and A. C. Haddon; British Museum.]

Description.—Corallum forms rounded masses, the lower edges closely adhering and bending under.

* See J. L. Duerden on Boring Algæ in the Bull. Amer. Mus., vol. xvi. (1902) p. 323.

Calicles (fig. 9) deep, subcircular, 2·5–3·5 mm. across. Walls nearly vertical, fenestrated, composed of a light delicately filamentous reticulum, ragged seen sideways, full of meshes seen from above, and with fine septal spikes projecting here and there from the margin, though a symmetrical radial arrangement is not visible either in the striæ on the top of the wall, or in projecting ridges round its edges. A little way down within the calicle the septa become visible as thin rows of delicate filamentous teeth which eventually meet, interlace, and, putting out lateral projections, form a large, exquisitely delicate, filamentous columellar tangle. Some 6–10 septa are early pronounced, but they as a rule slope down with ragged edges on to the columella, without the formation of any rosette of pali, although their teeth may show a tendency to bend up. Only in the lateral shallow calicles does this prominence of certain septa result in the formation of the rosette. In these lateral calicles the walls are thick and so delicately and irregularly reticular as to be almost woolly, the septa are in complete numbers, and jagged and pointed, and the columellar tangle is large and the pali rise as large irregular portions of its own jagged reticulum.

The vertical section shows highly perforated septa, open reticular walls, and delicate tabulæ (see Pl. III. fig. 2).

There are three specimens grouped together which have characters running into one another so perfectly that it is necessary to class them together in spite of their differences. Fig. 9, Pl. II. and fig. 2, Pl. III. relate to specimen *a*; fig. 1, Pl. III. is from specimen *b*.

The differences between *a* and *b* are accidental. Specimen *b* had died down at the top (? killed by some foreign body), but from all round the dead patch the colony is creeping in to cover it over. Some of the new calicles bending round on films of epitheca can be seen to be continuous with those which bordered the dead patch, having apparently just escaped the fate of those more centrally placed. There is a sort of slight cushion-shaped growth all round the dead patch, and in the deep calicles of this growth the septa are seen to be much coarser and stouter than in *a* (see Pl. III. fig. 1), and the same is the case with the wall reticulum. These calicles in fact approach the deep funnel-shaped type with thick sloping septa and obscure columella. But the dead calicles which were being covered up had thin septa and delicate reticular walls and columellar tangle as in *a* (Pl. II. fig. 9). And the lateral calicles are also like those of *a*. *Here then we have distinct evidence of structural variation being due to an accidental departure from the normal method of growth.*

The third specimen, *c*, is a very young colony some 3 cm. in diameter, but showing the edges of still earlier growths, the smallest of which was little more than 1 cm. in diameter. This specimen seems only to differ in the reticulum being not quite so delicate and woolly. The skeletal elements are more disposed to be knobbed, and in the lateral calicles the pali are rather more solid.

In all three the septal apparatus has essentially the same character, consisting of rows of fine filamentous teeth which put out lateral processes; these interlace to form a large delicate columellar tangle. The rosette formation is confined entirely to the lateral calicles.

The woolly character of the walls, which can only be seen by a lens, is well shown in the magnified fig. 9, Pl. II.

a. Warrior Reef. Coll. W. Saville-Kent. Zool. Dept. 92. 12. 1. 148.
b. "Great Barrier Reef." Coll. W. Saville-Kent. Zool. Dept. 92. 12. 1. 509.
c. "Torres Strait." Coll. A. C. Haddon. Zool. Dept. 1902. 9. 9. 5.

22. **Goniopora Great Barrier Reef** $_{(12)}$**8.** (Pl. III. fig. 3; Pl. XI. fig. 13.)

[Exact locality not given, coll. W. Saville-Kent; British Museum.]

Description.—Corallum is an irregularly flattened cushion shape, with sides tending to bulge and overhang. Lower edges creep under, close up to the base of attachment.

The calicles are polygonal and subcircular, deep and very irregular in size, from 2–2·5 mm. (double calicles, 4–5 mm.). Walls stout, but not thick, very fenestrated, built of rows of thick nodulated trabeculæ, and with very ragged, denticulate edges which, seen from above, are crossed by septal plates in single rows without radial symmetry, but set at all angles, some being bent, others forking and fusing together (fig. 3). These irregular septal plates give no clue as to the number of the septa. Six primaries are prominent as rows of thick, rough, granular projections. These descend into the calicles without forming pali (except in the lateral calicles). The secondaries are rudimentary, while the tertiaries are only present in faint traces. In the lateral calicles, which appear slightly larger and shallower, a distinct rosette of very prominent rod-like pali is formed. It surrounds a large fossa, the pali rising symmetrically near the walls, which are thicker and have two rows of coarse irregular granules separated by a median furrow. In the calicles on the top the columellar tangle is deep down, and obscured.

This coral seems to exemplify the pulvinate method of growth, but there is only one slightly flat-topped mass with bulging overhanging sides, and buds are numerous, even among the lateral calicles, which are not very shallow; cf. the diagram C, Introduction, p. 24. In the present case the most recent layer completely covers over the previous growths, so that the resulting stock does not form the pile shown in the diagram, but a more evenly shaped mass.

The special calicles are interesting for the fact that the septal plates which appear in the wall have lost their radial symmetry, which is only partially recovered in the lateral calicles (see Introduction, p. 19, on the tendency of the lateral calicles to return to (or retain) primitive characters).

a. Zool. Dept. 92. 12. 1. 420.

23. **Goniopora Great Barrier Reef** $_{(12)}$**9.** (Pl. III. fig. 4.)

[South of "Wreck Bay," in the outer edge of the reef, coll. J. B. Jukes; British Museum.]

Description.—Corallum massive, with smooth round top, edges thin and partly free.

Calicles polygonal, large up to 4 mm., open, deep. Walls thin, here smooth and membranous, there fenestrated; edges finely and irregularly denticulate, sometimes nearly straight, at others irregularly zigzag. Thin septal ridges appear round the margin, and descend straight down as thin, very denticulate and perforate ridges, the primaries and the slightly less developed secondaries curving round before joining the columellar tangle. The tertiaries are

rudimentary, but can be seen bending round towards the secondaries to make the typical formula. The columellar tangle is large, but loose and open, and only begins to show signs of pali towards the edges, where, in some parts, the calicles are shallower, and show the rosette formation. In other parts the lateral calicles remain quite deep, and retain the special characters of the topmost calicles.

There is only one fragmentary specimen, which is specially interesting because, having been injured at one time, growth processes are shown which are not often seen. When gathered the living layer was a small encrusting cake with free edges growing on the top of a fragment of a massive growth of unknown shape and size. This large original stock had apparently been killed down, and the new growth started *from a few of its topmost calicles*, as can be seen from a vertical section; cf. the pulvinate method of growth, Introduction, p. 24, diagram C. But in this case the cushion formation may have been purely accidental.

The section also shows well-developed tabulæ, the first being 6·5 mm. below the surface; this, therefore, was the real depth of the calicle.

An old label suggests the identification of the specimen with the *Goniopora* from New Guinea, called "*G. pedunculata*" by Quoy and Gaimard. See, however, the remarks on p. 37.

a. Zool. Dept. 46. 7. 30. 18.

24. **Goniopora Great Barrier Reef** $_{(12)}$**10.** (Pl. III. fig. 5; Pl. XII. fig. 2.)

[Thursday Island, coll. Saville-Kent; British Museum.]

Description.—The corallum is a symmetrical, smooth, oval mass, whose edges curl under as far as the base of attachment.

The calicles, sub-polygonal or circular, are fairly uniform in size, slightly over 2 mm., very deep. The walls are thin, membranous, and perforated by immense round or oval holes, which are very irregular in size and arrangement, so that there are no straight trabeculæ in the walls. Their upper edges are very irregular, being not only deeply incised by the perforations, but the intervening denticulations are irregularly thickened towards one calicle or the other by the rudiments of the septa. The three cycles distinct as rows of long irregular filamentous spikes projecting from the walls, all of them very rudimentary until deep down in the base of the fossa, where the radial symmetry is obscured by their bendings and fusions. The secondaries are less developed than the primaries, and the tertiaries persist as rudiments. The fusions of the septa are too irregular to show the typical septal formula. The tangle resulting from the meetings and fusions of the septa can hardly be said, except in the shallow lateral calicles, to condense into any definite axial structure, but to be loosely spread over the whole base, with a few large irregular interseptal loculi around the wall not radially arranged. In the shallower lateral calicles large smooth pali-form knobs arise almost to the top of the wall, and form conspicuous star-like groups in the midst of which the columella, though of stouter threads, persists as an open reticulum.

This coral is at first sight very like the specimen called by Mr. Quelch "*G. tenuidens*" (see *G. moluccas 1*). The form and general aspect agree, and the very fenestrated edges of the walls, which are sufficiently remarkable, are somewhat alike. On the other hand, the character of the septa and the absence of the pronounced plate-like pali in the deeper central calicles in this case show that the two are not very nearly related.

This specimen also is noteworthy because, as far as I can see, there is nothing but the star-like group of pali in the shallower lateral calicles to distinguish it from an Alveopore. The highly fenestrated, almost membranous walls and the filamentous septa, and the light columellar tangle are in every respect similar, and it is only the appearance of the structure just mentioned which gives one any confidence in placing it in this genus. This case of resemblance between forms belonging to such widely different genera is worth recording (see Introductory Remarks, p. 2), and in this case it is of special interest, because *Alveopora* was for a long time placed among the Poritidæ (see further Table IV. B (*b*) γ, p. 180).

a. Zool. Dept. 92. 12. 1. 166.

25. **Goniopora Great Barrier Reef** $_{(12)}$**11.** (Pl. III. fig. 6; Pl. XI. fig. 14.)

[Torres Strait, (?) exact locality, coll. A. C. Haddon; British Museum.]

Description.—Corallum forms small erect hemispherical knobs, with short thick stalks, the stock appearing to be formed of so many cap-like growths, one fitting into the other, the edges either closely encrusting or sharp, free and pendent, with a projecting epitheca (see Pl. III. fig. 6) which may bend over as the edge dies.

Calicles deep, conical, about 2 mm., open, irregularly angular or subcircular. Walls on the top thin, irregularly denticulated by the tips of stout trabeculæ, fenestrated, slightly zigzag; rapidly thickening at the sides of the stock where they are striated by septal plates or granules which are often symmetrically arranged as two alternate systems. Young calicles in the angles as shallow breaks in an irregular reticulum. Twenty-four septal ridges of blunt frosted teeth, or rounded granules, appear on the inner faces of the walls at the margin, but lower down only primaries and secondaries, the former, slightly more prominent, meet the columellar tangle, on which, in the more lateral calicles, appear irregular coarse paliform granules. The typical formula is obscured.

This coral belongs to the group in which the calicles are deep, and without the rosette formation except near the edges (see Table IV. p. 178). The six prominent primaries do not send up paliform teeth or plates.

There are three specimens, respectively about 2 cm., 3 cm., and 4 cm. in diameter; the largest (*a*) shows some five or six successive caps. These caps appear to represent so many repetitions of the primitive growth-form (see Introduction, p. 23), with the base concave rather than flat, but this need be only an accidental variation.

The cap formation is explained in the Introduction (p. 24).

Specimen (*a*) retains traces of a rose-pink coloration (cf. *G. Loyalty Island 1*).

a, *b*, *c*. Zool. Dept. 97. 3. 9. 91.

26. **Goniopora Great Barrier Reef** $_{(12)}$**12.** (Pl. III. figs. 7 and 8.)

[Warrior Reef, "extreme low water," coll. Saville-Kent; British Museum, and Australian Museum, Sydney.]

Goniopora fruticosa, Saville-Kent, Rec. Austn. Museum, vol. i. (1891) p. 123, pl. xv. figs. 1–4; pl. xvi. fig. 1.
Rhodarœa fruticosa, Saville-Kent, 'The Great Barrier Reef,' 1892, p. 187.

Description.—Corallum appears to have been primarily thin and encrusting, but the edges tend to run out into tongues, from the surface of which angular knobs arise, which flatten and divide. In this way low branching tufts may be formed, the terminals of which are about 1 cm. long and 1 cm. thick, angular, and rather closely packed. The chief stems are also thin, short, and often flattened. The living layer is 4–5 cm. deep.

The calicles on the more evenly encrusting portions (see Pl. III. fig. 8) are nearly subcircular, open and shallow, with visible flat floors, variable in size, 2 mm. being the largest. Walls, a close not conspicuous reticulum, on their tops and margins the septal striæ are usually very marked. These latter descend vertically to the floor, which consists of a very large columellar tangle, separated from the wall by great numbers of very small interseptal loculi. The irregular frosted twisted granules, which represent the pali, tend to form a clear circular ring rising up in the centre of the columellar tangle, within which ring the skeleton may be either nearly solid, or so light as to suggest a central fossa. On the rising knobs the skeletal elements are light and reticular, and the septal elements tend to disappear in the open reticulum.

On the tuft formations the calicles differ considerably from the above description (see Pl. III. fig. 7).* They are mostly drawn out of the shape and are much shallower. The septa again appear mainly on the tops and at the margins of the walls, but the latter have lost the symmetry of the septal striæ, and consist of an irregular, rather dense, flaky reticulum. The columellar tangle is large, and forms a floor to the open shallow calicles, but the symmetrical ring of pali only appears in calicles which are less drawn out of shape. The same variation as described for the more normal calicles is again seen within this central ring. The skeletal elements at the terminals of the tuft-formation though open are stout and not especially friable.

These specimens are very instructive. There is (*a*) an encrusting specimen which has sent out one long thick tongue, the upper face of which carries a constricted knob as if it were the continuation of the tongue. *The calicles on this specimen are of the same type as are those on G. Great Barrier Reef 1, which was also encrusting, and sent out tongues which curled round to form knobs* (cf. Pl. III. fig. 8 and Pl. II. fig. 1). The same general change of character takes place in both cases between the calicles on the encrusting parts and on the knobs.

In the present case the specimen (*a*) might easily have been separated from the tuft (*b*) under a new heading, but the characters of the calicles can be seen to be essentially identical.

* The figure has been accidentally inverted

Further, an analysis of the growth of the tuft showed fairly clearly that it could be deduced from a secondary proliferation of the curling-up edges of an encrusting growth. The thickness of the skeletal elements at the tips of the tuft is doubtless an adaptation for strength. The growth-form is figured by Mr. Saville-Kent (*l.c.*).

We gather from the original description that the polyps are very extensile, and that the 24 tentacles are long and "awl-shaped." The oral disk is white, the column and tentacles a clear liver-brown. Found at extreme low water.

a. An encrusting form.	Zool. Dept. 92. 12. 1. 167.
b, *c*, *d*. Fragments of a tuft.	„ „ 92. 12. 1. 214.

27. Goniopora North-West Australia (6)1. (Pl. III. fig. 9.)

[Broughton Island Reef, 13° 44′ S., 126° 11′ E., coll. Bassett-Smith; British Museum.]

Description.—Corallum nearly globular, descending edges may, however, hang free, each with a well-developed epitheca.

Calicles small, 2·5 mm., about 2 mm. deep, subcircular and polygonal. The walls in the uppermost calicles thin, sometimes membranous, and seen from above as a single stout thread. Seen from the side they appear as if built up of stout, closely packed trabeculæ, with a few oval perforations. Elsewhere their upper edges are made ragged by the tops of the septa running across them irregularly and at all angles, the radial symmetry being obscured (fig. 9). The walls of the lateral calicles are thicker, owing to the greater exsertness of the septa, which, however, seldom form a double row. The septa appear in three cycles round the margin as uniformly but feebly developed points. Below the surface the primaries soon become conspicuous, and project inwards to form the columellar tangle. The secondaries appear to reach the columella at a deeper level. The tertiaries persist as rows of minute points which, however, bend round here and there towards the secondaries to form the typical formula. The interseptal loculi are large and open, and the skeleton is consequently not very compact; the upper edges of the primaries form a somewhat conspicuous star of rather inconspicuous paliform plates or spikes, rising but slightly round the columella, which is large but loosely composed of broad twisted flakes. In the lateral calicles the columella is a solid mass nearly filling the shallow fossa. The primaries radiate as rows of minute points over its surface. The whole of the skeleton—walls and septa—is very thin and delicate. In section the reticulum is close and solid. Tabulæ very delicate.

This coral is quite distinct from all the others represented in the collection. It is small, being about 4 cm. high, and the same in transverse diameter. There appear to be only two edges, indicating one previous growth. The colony, when the first was formed, was 2·5 cm. transverse diameter, and this seems to be but loosely covered by the more recent edge.

In the slight development of the pali in the deeper calicles, this coral stands midway between those with deep calicles and conspicuous but not pali-forming primaries and those in

which the rosette of pali are the chief representatives of the intracalicular skeleton. The incipient rosette is distinct, but its elements are not pronounced.

A similarly irregular cross striation of the walls by the tops of the septa may be seen in *Goniopora Great Barrier Reef 8* (Pl. III. fig. 3), but the skeletal elements are there thicker and coarser, and the rosette formation is entirely confined to the lateral calicles.

a. Zool. Dept. 92. 1. 16. 31.
Presented by the Lords of the Admiralty.

28. **Goniopora North-West Australia** $_{(6)}$**2.** (Pl. IV. fig. 1; Pl. XI. fig. 15.)

[Bassett-Smith Shoal, Holothuria Reef (9 fathoms), coll. Bassett-Smith; British Museum.]

Description.—Corallum explanate, variable thickness, 2–4 mm., with smooth wavy surface, encrusting edges 1–2 mm., bent under (? seldom free).

Calicles very small, faint, shallow depressions, 1·5–2 mm. across, of indefinite shape, mostly polygonal, with minute central fossa. The whole surface a compact mosaic of very minute granules. The walls slightly raised, solid looking and covered with minute frosted flakes and granules; the septa slope down from the wall-ridges. The long narrow interseptal loculi, though running right to the ridge between adjoining calicles, seldom pass into one another. The compact septa consist of 24 radial series of granules. The primaries with as many as 5–6 in a series, and all of them so arranged as sometimes to allow the intervening spaces to form concentric rings round the fossa. The arrangement of the granules further shows the typical septal formula, with its proper fusions. They slope, as a rule, evenly down towards the fossa, but here and there faint traces of a central boss can be seen.

The texture in section is very close and dense, but composed of very delicate skeletal trabeculæ, the tips of which form the granules.

But for the presence of the 24 septa arranged in the typical formula, this might be taken for a *Porites*. Its label bore the provisional name *Porites arenosa*. It is quite an extreme form among known recent Goniopores, although when more forms from deeper water are known its specialisation may be found to be common. See observations under the next form. On the correlation of its type of calicle with the thin explanate growth, see Introd., pp. 23 and 24, and Table IV. p. 178. The diminution in size of the calicles, coupled with the retention of the full septal formula, is a point of interest when the origin of *Porites* from *Goniopora* by a process of reduction in the number of septa is taken into account. It shows that the reduction need not necessarily be an adaptation to diminished size. (Cf. Introduction, p. 21.)

Equally interesting, too, are the possible relationships between this form and the three following. They suggest a series, although there should be some intermediate form between this and the next to make it complete; on this series see p. 63.

a. Zool. Dept. 92. 1. 16. 45.
Presented by the Lords of the Admiralty.

29. **Goniopora North-West Australia (6)3.** (Pl. IV. fig. 2; Pl. XII. fig. 3.)

[Holothuria Bank (15 fathoms), coll. Bassett-Smith; British Museum.]

Description.—Corallum explanate, with smooth upper surface, about 4 mm. thick, closely encrusting, edges thin, seldom free, stout epitheca.

Calicles large up to 5 mm., shallow, polygonal. Walls as thick (1 mm.) raised ridges. The septa rise to the ridge of the wall, and the interseptal loculi may run into one another over the ridge; sometimes parts of a fourth cycle appear; as a rule the typical formula can be easily made out (Pl. IV. fig. 2). The upper edges of the septa are rows of granules or teeth, and slope downwards at various inclinations, sometimes with slight concave curves, towards the centre, where there is a slight fossa; this is usually, but not always, surrounded by a rosette of pali. The individual pali are often seen to be groups of fused granules at the points of fusion of the septa. At the creeping edges the rows of septal granules run out over the walls to the edges of the projecting epitheca.

The texture in vertical section is coarsely trabecular.

This Goniopore bears no superficial resemblance to the last, and yet there is a fundamental agreement in essential structure which cannot be overlooked. Its shallow calicles, the granular character of the edges of the septa, and the central fossa, suggest, especially where there is no central rosette, that if the structural parts were only on a much smaller scale, the two would be almost indistinguishable from one another. The difference seems in essence to be almost entirely one of size. Cf. Introduction, pp. 23 and 24, on the interdependence between growth-form and type of calicle. See further on the possible serial relationship of this coral with the next two following, p. 63.

It is noteworthy that this coral comes from a greater depth than the last with the smaller flatter calicles. Two other *Gonioporæ* with very flat calicles come from great depths: *G. China Sea 2*, 31 fathoms, *G. Maldives 1*, 32 fathoms.

30. **Goniopora North-West Australia (6)4.** (Pl. IV. fig. 3; Pl. XII. fig. 4.)

[Holothuria Bank (15 fathoms), coll. Bassett-Smith; British Museum.]

Description.—Corallum encrusting, with convex centre, and edges curving concavely upwards (cf. fig. 2, Diagram A, Introduction, p. 24), with slightly projecting and overlapping epitheca.

Calicles large and open, up to 5 mm., about 1 mm. deep, polygonal on the top, but sometimes subcircular near the flattening edges.

Walls steep and thin but strong, and where simple, a close zigzag is visible under the pocket-lens; the tips of the septa make the edges bluntly denticulate. The zigzag synapti-

cular junctions more delicate than the septa. In the lateral calicles the wall is thickened by an extra row of septal granules one on each side of the median ridge, the latter showing traces of points joined by a delicate zigzag thread. The three cycles of septa, nearly equally developed round the margin, are rows of stout rough granules, which usually descend steeply and then curve round towards the large columella, which consists of a tangle of flakes and looks nearly solid. The typical formula can be made out, but the points of fusion of the septa are imbedded in the columellar tangle. Scattered granules rise from the surface of this latter, and here and there group themselves roughly into a rosette, occasionally with a central knob in line with the directives.

This coral, which was developing upon a dead Turbinarian, seems to form a transition between that last described and the next following. The walls are slightly steeper, thus making the colony convex instead of flat and explanate, but otherwise the calicles seem to be built on the same plan, the septa having similar granular edges and similarly running up the walls, only here delicate synapticulæ form a zigzag line. At the edges of the stock the rows of septal granules run over the walls and out to the edge of the epitheca.

a. Zool. Dept. 92. 1. 16. 25.
Presented by the Lords of the Admiralty.

31. Goniopora North-West Australia (6)5.

[Holothuria Bank (15 fathoms), coll. Bassett-Smith; British Museum.]

Description.—Corallum massive, with smooth convex surface, edge closely encrusting and not bending down far.

Calicles large, variable in size (up to 4·5 mm.), deep 2·5 mm., but open, angular, and with broad flat floor, on to which the septa slightly slope. The wall has a stout rough edge, composed of the granular tops of the septa, which are usually irregularly united, but frequently form a single row, even in the lateral calicles. The 24 septa, all equal in size round the margin, are straight rows of stout rough granules which descend with a slight slope (or else straight with a concave curve at the bottom) to the columellar tangle. The points of fusion of the septa are all involved in the immense columella, which seems to be composed of large flat flakes with wavy and slightly curled edges. Small scattered granules, or else the turned up edges of thin flakes, are here and there arranged into a radial rosette, which though almost everywhere seen in traces is nowhere really pronounced.

This coral is unfortunately not a very good specimen. It was evidently growing continuously with a rather shapeless fragment of a former growth which had suffered from foreign organisms. It seems to carry on the series in which the last two corals are stages. The stock is still more convex and the calicles deeper, that is, have higher walls, and the central rosette is less conspicuous. All three are united by the sizes of the calicles, by the type of internal skeleton, and by the symmetrical septa whose top edges are broken up into rows of

granules rather than teeth. In the first the stock is explanate, the calicles shallow, and the rosette conspicuous; in the second the stock is convex in the middle, the calicles are deeper, but the rosette is hardly different; while in the third, the stock is convex and massive, and the calicles are still deeper, and the rosette less conspicuous. Further, this series is made more interesting by the presence of the extreme explanate form, *Goniopora N. W. Australia 2* with small calicles, but with the compact septa edged with granules so that owing to the closeness of the skeleton the whole surface seems to be a compact mosaic of delicate frosted granules. Cf. on the interdependence of growth-form and type of calicles, Introduction, p. 24.

All these forms come from the same locality, and it may be that we have here another case of that strange family likeness between corals from the same locality which we have already noted in former volumes (see Vol. II. p. 18). In those cases, however, the resemblance was largely in superficial texture, but here it seems to be more fundamental than superficial.

All these (except the first) differ from the specimen now to be described from King's Sound, in having larger calicles and a full number of septa.

a. Zool. Dept. 92. 1. 16. 32.

32. **Goniopora North-West Australia** $_{(6)}$**6.** (Pl. IV. figs. 4, 5, and 6; Pl. XII. figs. 5 and 6.)

[King's Sound, coll. W. Saville Kent; British Museum.]

Description.—Corallum forms globular masses, edges being everywhere closely encrusting and bending round under the stock.

Calicles average 3 mm. in size, varying from polygonal to subcircular, 3–4 mm. deep; more open, shallow and cup-shaped at the sides. Walls of the deeper calicles at the top very steep, varying in character and thickness, being either thin and lattice-like, straight or slightly zigzag, with denticulate edges (Pl. IV. fig. 5), or greatly thickened, reticular, with rounded tops, the reticulum being symmetrical and showing a straight row of meshes running on each side of the median ridge which is often zigzag (Pl. IV. fig. 6). Septa seldom traceable as striæ across the wall. Round the margin of the calicles twelve symmetrical and finely toothed striæ run down the steep walls; all appear typically to curve concavely inwards towards the reticular columella, the teeth often tending to bend up slightly, but not sufficiently to form true pali; sometimes the primaries are more pronounced, both being thicker and projecting further than the secondaries. The tertiaries are very rudimentary, only just visible round the margin, but, in the shallower lateral calicles, they are well marked and project regularly into the interseptal loculi and, bending round, complete the typical formula. The columella is a distinct reticular tangle separated from the wall by a clear ring of twelve interseptal loculi. Sometimes it is convex, at others the septa project rather far above it, in which case it appears feebly developed. The straggling branching points of its surface become gradually pronounced into a rosette, which is very conspicuous in the lateral calicles, each palus being itself a jagged tangle, the symmetry of which, visible to the naked eye, becomes obscure under the lens.

These *Gonioporæ* differ from all the foregoing from Australia. There are three specimens. One very large, smooth, nearly globular mass, slightly flattened at the top, 10 cm. high and about 14 cm. in diameter (Pl. XII. fig. 5). Figs. 5 and 6, Pl. IV., are both from this specimen, and show the wall-variations on different portions of its upper surface. The lateral calicles are not shown. Fig. 4 is from another specimen (see Pl. XII. fig. 6), which had suffered somewhat from foreign organisms. For instance, in fig. 5, the columellar tangle rises up among the septa, but in fig. 4 the septa run over the top of it and obscure it. This may be another case of calicle variation due to abnormal growth conditions. One of the peculiar features of the large specimen is the symmetrical reticulum of the thickened walls, which shows a regularity of structure almost unique, and this not only laterally but over a large part of the upper surface where the calicles are very deep (cf. figs. 4 and 5 with fig. 6). These have lost their polygonal outline and become cylindrical, with apparently only twelve thin septa and large interseptal loculi.

This coral belongs to the group in which the calicles are deep and only form rosettes on the large, prominent columellar tangles in the lateral calicles.

a, *b*, *c*. Zool. Dept. 94. 6. 16. 10. 11. and 19.

33. Goniopora Australia *a*.*

['Les mers de la Nouvelle Hollande,' coll. Peron et Le Sueur; Paris Museum.]

Astræa calycularis, Lamarck, Animaux sans Vert., ii. (1816) p. 266.

Rhodaræa calicularis, M.-Edwards and Haime (non Quelch, see p. 68), Brit. Foss. Corals, Introd. (1850), p. 56.

Description.—Corallum convex, small, 3·5 by 2·5 cm., a well-developed epitheca round the new edges, which are 2 mm. thick.

Calicles round, deep, 3 mm. in diameter, cylindrical, with young calicles in the angles. The walls vary in thickness, when thin they are very fenestrated, built of septal trabeculæ arranged in a slight zigzag, when thickened they form an angular reticulum. The trabeculæ are slightly flattened and project so as to denticulate the inner margin. The three cycles of septa are incomplete rows of short sharp teeth. The primaries and secondaries seen from above alone curve forward to join the columellar tangle. This tangle is very pronounced, irregular in outline, appears almost solid and with knobbed surface, 5–6 of these knobs form somewhat thick angular pali. The centre is sometimes occupied by a tubercle, but always appears to fill up faster than the peripheral parts of the fossa.

This description is taken from the only coral I found in the Paris Museum which had any claim to be Lamarck's original specimen. It is a young colony, and interesting because except for *Mad. intersepta* (*v.* p. 160) it was the first *Goniopora* to be described, being placed among the Astræids by Lamarck. The chief structural feature of the specimen is the large, prominent, knobbed, and nearly solid columellar tangle standing up high in the fossa.

Peron's expedition did not touch the east coast of Australia north of Port Jackson, and there are no specimens from the western coast in the British Museum Collection from

* On the designation *G. Australia a* see the prefatory note to Group XIV. p. 156.

localities further south than King's Sound on the north-west. Hence I have provisionally placed this coral near the N.W. Australian group.

The description unfortunately gives no clue to the relationship of the coral with any of the six forms above described from that region. The specimen from Zamboanga, to which Mr. Quelch gave the name *Calicularis*, is described on p. 68. Mr. Saville-Kent, in his 'Great Barrier Reef,' p. 187, says that "*Rh. calicularis*" is common on the Great Barrier Reef. But I have been unable to identify any of the specimens from that locality with Lamarck's type.

Group III.—MALAY ARCHIPELAGO.

Containing descriptions or records of Gonioporæ from Moluccas (1); *Celebes* (1); *Philippines* (1–4); *China Sea* (1–5); *Java Sea* (1–4); *and Singapore* (1–6).

34. Goniopora Moluccas (1).1. (Pl. IV. fig. 7.)

[Amboyna, coll. H.M.S. 'Challenger'; British Museum.]

Rhodarœa tenuidens, Quelch (*partim*), Chal. Rep., xvi. (1886) p. 188, pl. viii. figs. 7, 7*a*, 7*b*.

Description.—The corallum massive, smooth, oval, apparently built up by successive cushion-like growths (see Introduction, p. 24, fig. 2*c*), each consisting of a thick (ca. 2 cm.) layer with bulging sides, and with its edge tending to curl under and not to envelop the whole stock.

The calicles are 3 mm. in diameter, subcircular, with cylindrical fossæ of varying depths up to 3 mm. Wall of unequal thickness, the thinner parts very thin, fragile, and so fenestrated as to form an open lattice-work with frilled ragged edges; the thicker parts, seen from above, are a delicate open reticulum, chiefly confined to their top edges, below which they appear membranous and very porous. Though the tops of the walls are reticular no radial structures can be traced across this reticulum (fig. 7), not even in the shallower calicles at the sides. Within the fossa, however, and below the margin, 24 septal ridges, or rows of short exquisitely fine points, run down the walls. From what appear to be the primaries thin irregularly radial paliform plates rise up, but do not reach to the top of the wall, except in small intercalicular buds. The secondaries (?) are merely rows of long thin spikes, often bent so as to fuse with the primaries. The tertiaries are minute hair-like points, set with broad bases on the wall. The septal formula is obscured. There is often a central tubercle, which in the deep calicles is a median directive plate. Owing to the rudimentary conditions of the tertiaries the interseptal loculi are conspicuous.

In the vertical section a striking contrast can be seen between the stout vertical and the horizontal elements of the skeleton. Tabulæ are very numerous.

The peculiarities of this coral are: (1) the "pulvinate" growth; (2) the neatly circular calicles; (3) the fact that the top edges of the walls are reticular, even though they appear below the edge to remain simple and membranous; (4) the nearly laminate primaries, with their conspicuous but thin paliform plates, which rise to within 1·5 mm. of the mouth of the calicle, except in the shallow lateral calicles and in young buds; (5) the spike-like secondaries and tertiaries, the latter being very minute.

There is one specimen, an almost symmetrical oval mass, about 9 cm. in long diameter. It is infested with calcareous worms, whose tubes coil about among the calicles, and mostly open without bending up free of the surface. For other specimens, showing the same neatly punctured cylindrical calicles and the star-like arrangement of pali, see Table IV. p. 180. They all differ in important points, in depth and size of calicles, in the thickness of the walls, in the character of the pali, in method of growth.

a. Zool. Dept. 86. 12. 9. 304.

See pp. 67, 68, 69 for the other specimens from Zamboanga, which Mr. Quelch classed under the same name with this coral.

35. **Goniopora Celebes** (1)**1.** (Pl. IV. fig. 8; Pl. XII. fig. 7; see also Pl. IX. fig. 3.)

[Talisse Isl., N. Celebes, coll. S. J. Hickson; Camb. Univ. Museum.]

Description.—Corallum forms large, smooth, oval masses, only the top covered by the living layer, and consequently great numbers of free thin edges with conspicuous epithecal bands, both supporting and pellicular.

Calicles as neat circular holes, 2·5–3 mm. in diameter and about 3 mm. deep. Walls vertical, finely denticulate, fenestrated by great numbers of minute pin-holes; thin, of nearly uniform thickness, and everywhere with upper edges of close angular reticulum, showing slight traces of radial symmetry. The septa visible as granules become cross striæ on the tops of the thicker walls of the lateral calicles. When these septal cross striæ are very conspicuous, those of adjacent calicles may be separated by a median furrow or line. An immense number of young intercalicular buds, often very deep, occur in the reticulum in the angle between the calicles. In the deep calicles the septa only appear as faint striæ below the edges, but lower down the primaries and secondaries are flat thin plates. The former run out to join the columella; an irregular number of secondaries generally developed; only very faint traces of tertiaries, just below the margin of the wall. Pali very irregularly developed, sometimes absent in the deeper calicles, in which case the intracalicular skeleton is very scanty; when present they form a symmetrical hollow ring of frosted plates or flattened knobs, beneath which is the open very inconspicuous columellar tangle. In the lateral calicles the pali are stouter and taller, more than usually conspicuous, sometimes with thinner pali alternating with the normal six and with a conspicuous central tubercle. In these lateral calicles the pali alone are thickened, and there is a strong contrast between them and the thin septa.

This coral is in the Cambridge University Museum. It is a large oval or fusiform mass, 25 cm. long and 14 cm. thick, on which the most recent of the living layers is a narrow ridge, only 5 cm. wide and over 30 cm. long, running from end to end of the stock and bent down at the ends (Pl. XII. fig. 7).

The general characters are very like those of the Amboyna coral just described. In both the thin walls tend to be finely reticular instead of being purely membranous, and the reticulum is of the same character in each; the growth-form too is closely similar. The chief differences are that in the deep calicles the large plate-like pali of the Amboyna specimen are hardly developed at all, but in both the pali-rosette in the lateral calicles is very highly developed—if anything, it is more conspicuous in this coral than in that from Amboyna.

Both corals show a tendency in the lateral calicles and round the edges of the stock for the septa (though very inconspicuous in the deep calicles) to overrun the walls, and in this coral there is a remarkable patch upon an earlier growth in which the whole character of the calicles is completely different. They are shown on Pl. IX. fig. 3 as *open, shallow, with broad mound-like walls, over which the ragged and wavy septa run from calicle to calicle, the columellar tangle being without pali, ragged and nearly flush with the tops of the walls.*

This is another instance of the ease with which the calicles may be transformed, although in this case I do not know of any representative of the genus with calicles exactly like those shown on this patch. In this coral, therefore, we have not only the special calicles on the top, but the lateral calicles showing the usual tendency to revert to the shallow thick-walled primitive type, and these abnormal calicles, which may be due perhaps to the proximity of other disturbing organisms. They show the primitive calicle modified in a way not so far known in any existing *Goniopora*.

36. Goniopora Philippines $_{(4)}$1. (Pl. IV. fig. 9.)

[Zamboanga, coll. H.M.S. 'Challenger'; British Museum.]

Tichopora tenella, Quelch, 'Challenger' Report, xvi. (1886) p. 189, pl. xi. figs. 1, 1*a*.

Description.—Corallum a smooth, erect, symmetrical knob, swelling evenly, with blunt rounded top. Edges not free nor easily recognisable, as they thin away upon an epitheca which follows the irregularities of the surface.

Calicles gaping open, shallow, subcircular, 4–5 mm. in diameter. Walls irregular in thickness up to 2 mm., forming low ridges of a loose open reticulum, with very irregular ragged upper edges, in which both septal and synapticular elements can, as a rule, be traced. In the wider portions of the intervening spaces between the calicles, the reticulum tends to surge up. The twenty-four septa nearly uniformly developed, thick near the wall, but thinning away towards the centre, with ragged upper edges and frosted sides. They run out just below the margin, and all join the columella, but the typical formula is conspicuous to the naked eye, the tertiaries being long, and the interseptal loculi clear and conspicuous. The columella is a large, conspicuous, convex mass of loose filamentous reticulum, rising into delicate free granulated ends, which only here and there show any disposition to form sex-radiate groups. The columellar tangle is in sharp contrast with the symmetrical ring of dark slit-like interseptal loculi and with the rather thick conspicuous septa.

In vertical section the septa are seen to be a delicate lace-work, with perforations so large and round that the skeletal matter is reduced to threads. Continuous vertical strips (trabeculæ), however, run up in the wall and in the columella. The whole is very light and porous. A tabular floor runs through the corallum, about 6–7 mm. below the surface.

There is only one small specimen of this coral, which was the type of Mr. Quelch's genus *Tichopora*. There is, however, no structural character which would justify its removal from the genus *Goniopora* (see Introduction, p. 16).

The specimen is only 4·5 cm. high, and about 3·5 in diameter at its thickest part.

The most striking features are: (1) the symmetry of its growth, which forms a kind of transition from the hemispherical to the columnar; (2) the regularity and symmetry of the septa seen from above (see fig. 9); (3) the conspicuous interseptal loculi; (4) the large reticular columella; and (5) the inconspicuousness of the creeping edge.

The growth-form may be due to the smallness of the object on which the colony first settled (cf. the nearly similar forms assumed by some of the fossil forms (e.g. *G. Sussex 1*) when settled on very small pebbles). Further, the calicles of these two corals are not unlike.

For the Goniopores with large open calicles and well-developed columellar tangle, see Table IV. E, p. 181.

In fig. 9, the directives of the calicle on the left-hand lower corner run diagonally across the figure from the left below, and a trough runs across the columellar tangle in the same plane. The pali typically consist of two rows of three, one on each side of the directive plane.

a. Zool. Dept. 86. 12. 9. 342.

37. Goniopora Philippines (4)2. (Pl. V. figs. 1 and 2.)

[Zamboanga, coll. H.M.S. 'Challenger'; British Museum.]

Rhodarœa calicularis, Quelch (*non* Lamarck, see p. 64), Chall. Rep., xvi. (1886) p. 188.

Description.—Corallum massive, rounded, slightly flattened at the top, with smooth, slightly wavy surface, with hardly any trace of edges. A pellicular epitheca creeps up the steep dying sides, and sinks deeply into the calicles.

The calicles vary in size, mostly under 3 mm.; deep, alveolate, polygonal or angular on the top, shallow and subcircular at the sides. Walls on the top (fig. 1) thin, vertical, almost membranous, fenestrated, and with denticulate edges, not thickened in the angles except where young buds are forming. On the sides (fig. 2) the walls are thicker, and the tops show rows of narrow septal plates. Septa everywhere obscure, hardly visible on the membranous walls of the deep calicles, just visible as striæ on the shallow lateral calicles. Deep down a few thin, twisted, angular threads run out to join the columellar tangle, which, as a very irregular, nearly solid tangle of coarse threads, knobs, and granules, in which a six-rayed pattern can be detected, nearly closes the base of the calicle. This columella appears flat, and without paliform prominences in the deeper calicles, but in the shallower there is a somewhat symmetrical ring of stout knobs rising from a nearly solid base.

In the vertical sections of the stock the walls, as long stout lamellæ with minute pores, are in striking contrast with the light axial reticulum which forms the intracalicular skeleton. The septa are hardly recognisable, being merely the threads which attach the reticulum to the walls.

The single specimen of this coral was named by Mr. Quelch "*Rhodaræa calicularis*" Lamarck and Milne-Edwards and Haime. But the descriptions given by the latter authors of the method of growth, and of the large calicles with prominent pali, which last are here only present in the lateral calicles, hardly agree.

The specimen is a sector knocked out of a nearly globular mass, which must have been 20 cm. across and some 14 cm. high. Its method of attachment is not shown.

In the details of its structure it stands quite alone. The thin lamellated walls of the calicle on the top give it a honeycomb appearance not common in the genus, while in vertical section the reduction of the intracalicular skeleton to a delicate axial reticulum, in strong contrast with the solid walls, is quite a remarkable feature.

The lateral calicles well exemplify the rule that in reverting to the primitive type they are modified, so as to have a strong family likeness to those characteristic of the specimen. (Introduction, p. 25.)

a. Zool. Dept. 86. 12. 9. 305.

38. **Goniopora Philippines** (4) **3**.

[Santa Cruz Major Island, off Zamboanga, 10 fathoms, coll. H.M.S. 'Challenger'; British Museum.]

Rhodaræa tenuidens, Quelch (*partim*), Chall. Rept., xvi. (1886) p. 188.

Description.—Corallum almost globular, enveloping the point of a calcareous algal concretion, with edge either closely encrusting or freely drooping, with prominent epitheca.

Calicles slightly funnel-shaped, 3 mm. across and about 2 mm. deep. Walls simple, stout, and very fenestrated, frilled and ragged at the edges; the trabeculæ composing them being thick and of irregular outline and joined irregularly, sometimes in a slight zigzag. The septa are very irregular interrupted rows of small frosted knobs or jagged flame-like points. The three cycles are distinct. The primaries and secondaries project in the base of the calicle to form a very open ill-defined columellar tangle from which the pali arise as tall, frosted or jagged, slightly flattened and twisted points. A central tubercle is sometimes developed. The whole columellar tangle rises up on the base of the fossa. The fusions of the septa are deep down and obscure, parts only of the typical septal formula can be made out.

This is quite a young specimen, interesting because revealing the growth-form of a very young colony. It shows no very close resemblance to any of the other Goniopores from the Philippines, nor to the form from Amboyna (*G. Moluccas 1*), with which Mr. Quelch classed it. There are no delicate filamentous septa and conspicuous plate-like pali, and the walls are much stouter; see Table IV. C, p. 180.

a. Zool. Dept. 86. 12. 9. 308.

39. **Goniopora Philippines** $_{(4)}$ **4.** (Pl. V. fig. 3.)

[Mactan Island; coll. H.M.S. 'Challenger'; British Museum.]

Goniopora pedunculata, Quelch (non Q. & G.), Chall. Rept., xvi. (1886) p. 187.

Description.—Corallum apparently a thick encrusting cushion-shaped layer, of irregular outline, with smooth but wavy surface and character of edges unknown. The thickness varies quite irregularly from 1·5 to 3 mm. according to the surface of the substratum.

Calicles about 2·5 mm. across, showing two types of structure. On the thinner parts of the stock they are open, rounded, rather shallow, with vertical walls descending upon a flat floor (fig. 3). The walls are fairly regularly composed of compact thick septa, with stout synapticulæ. On the thicker parts of the stock the calicles are deep and funnel-shaped, and the stout walls are a close reticulum showing no signs of regular formation out of radial septa and concentric synapticulæ, which have melted together. Young buds are mostly confined to this region. The 24 septa project almost from the margin as short stout points and knobs. In the deep conical calicles they descend as thick, vertical rows of knobbed and irregular projections, sloping gradually and only very deep down uniting with an inconspicuous tangle. In the shallower calicles (fig. 3), without previously projecting into the fossa, they unite with a large flat conspicuous columellar tangle which is so flaky as to appear nearly solid. There is a ragged reticulum on its surface in which here and there a six-rayed arrangement can be detected, while round it and close to the walls the ring of interseptal loculi is fairly conspicuous, because some of them are large. The typical septal formula can here be made out.

In sections the calicles and the different elements of the skeleton are hardly distinguishable.

The fragment was identified in the 'Challenger' Report with *G. pedunculata* Q. & G., but see p. 36 on the possibility of re-identifying this coral.

The two kinds of calicles are especially interesting—shallow, with walls regularly built, and deep and conical with an irregular reticulum foaming up round them. This latter is probably a sign of rapid growth, a suggestion confirmed by the presence at this part of many young buds. The regular shallow type on the thinner part of the stock recalls those of *G. Great Barrier Reef 1*, p. 48 (see Pl. II. fig. 1), although there the stock is still thinner and the calicles larger and shallower.

a. Zool. Dept. 86. 12. 9. 306.

40. **Goniopora China Sea** $_{(5)}$ **1.**

['Mers de Chine,' 1839, coll. Lagrenée; Paris Museum.]

Rhodarœa ? lagreneei, M.-E. & H., Ann. d. Sci. Nat. (3°) xvi. (1851) p. 43; *non* "*Rh. lagrœnei*," Brüggemann, Abh. Ver. Brem., v. (1878) p. 547 (= *G. Singapore 1*, p 79).

The original specimen of this coral seems to be Z. 205*a* of the collection in the Paris Museum. As stated by Milne-Edwards, it seems to have been very worn. In shape it appears

to have been columnar ("élevée et lobée"). The calicles are large, 4–4·5 mm., polygonal; the walls are an open reticulum on the top, more solid at the sides. The fusions of the septa are very conspicuous.*

41. **Goniopora China Sea** $_{(5)}$**2**. (Pl. V. fig. 4; Pl. XII. fig. 8.)

[Macclesfield Bank, 31 fathoms, coll. Bassett-Smith; British Museum.]

Description.—Corallum explanate, starting from a small centre of attachment, forms a very thin leaf slightly crumpled and of quite irregular outline, with lobate edges, uniformly about 1 mm. thick, everywhere supported by a stout wrinkled epitheca. Fresh growths seem to start somewhere near the centre and to carry out the corallum beyond the old edge, but apparently without seriously increasing the thickness.

Calicles 2·5 mm. across, polygonal, flush with the surface. The walls hardly raised; the septa of adjacent calicles sometimes meet across them, and allow free communication between the interseptal loculi. The upper edges of the 24 septa are rows of fine uniform granules, arranged in the typical formula, fusing in the typical manner. Between the three pairs of stouter granules representing the six typical pali, the directives are continued right across the calicles by a row of smaller granules; these central granules completely fill up the fossa and sometimes even suggest a slight central boss. The interseptal loculi are uniformly narrow, and vary in length, owing to the fusions of the septa; the peripheral ends of the septa are frequently so thickened that the granules on their edges may appear double as if the septa were again forking near the wall (cf. *G. Paris Basin 2*, p. 133).

The thin section is a close uniform reticulum without definite arrangement, except that the vertical trabecular elements are slightly more pronounced than the horizontal. The colour of the unbleached stock is sepia. The details of the skeleton are best seen on the dead and bleached surface.

This is a very extreme form of *Goniopora*, and owing to its habit might be easily mistaken for a smooth *Porites*. The size of its calicles, with the 24 septa arranged according to the typical formula, show that it belongs to this genus. It differs from *Goniopora N.W. Australia 2* (see Pl. IV. fig. 1) in being much thinner, and in having calicles quite flush with the surface, and having no fossa. The granular character of the surface is obviously due in both forms to the exigencies of the case. In such shallow calicles passage between the vertical elements of the skeleton must be free and open. Both these interesting forms were discovered by Dr. Bassett-Smith.

a. Zool. Dept. 92. 10. 17. 96.
Lords of the Admiralty.

In the earlier drafts of this catalogue I called this coral "*Goniopora porititformis*," but that name would be equally suitable to the next form and also to *Goniopora N.W. Australia 2* above referred to, and also to *G. Maldives 1* (see Pl. VII. fig. 1).

* When I visited Paris I had not discovered the typical septal formula of the genus, and hence made no reference to it in my notes.

42. **Goniopora China Sea** $_{(5)}$**3.** (Pl. V. fig. 5; Pl. XII. fig. 9*a*, 9*b*.)

[Macclesfield Bank, 28 fathoms, coll. Bassett-Smith; British Museum.]

Description.—Corallum explanate, the first small circular colony forming the specimen was slightly convex. Later growths distorted, curled, and bent by foreign organisms.

Calicles 2–3 mm. across, nearly flush with the surface. Walls here distinct, being very slightly but somewhat sharply raised, there almost flush. In the former case built of irregular granules expanding into flat, jagged, horizontal flakes. Where flush these flakes run with nearly smooth surfaces (except for small sparse granules), but with ragged edges into the calicle. The septa are quite irregularly shaped out of these wall flakes, or out of those of a lower layer, or appear as small knobs from between the layers; parts of the typical formula, even with its fusions, can be seen here and there; radial symmetry greatly obscured, so that at times the calicles are hardly recognisable at all. From the irregular flakes forming the columellar tangle groups of granules arise, most prominent in those calicles in which the walls are prominent. They are very irregular, but not infrequently form a continuous ring with radial thickenings or offshoots.

In section the texture is a light large-meshed reticulum, in which the horizontal elements are flaky and more conspicuous than the vertical; vertical continuous trabeculæ are absent. The coral is very light and appears friable.

This striking modification of the typical skeleton, due to the development of its horizontal elements at the expense of its vertical, is rendered the more remarkable because there is a *Porites* from the same place with the same modification (see next volume, also Introduction, p. 20).

This remarkable resemblance between corals of two different genera in the same locality is not the only case I have discovered of this kind. Off the Amirantes there are Montipores and Porites (which will be described in Vol. V.) almost exactly resembling one another.

The single specimen has been distorted by Annelids, Balanids, and a large calcareous algal concretion. The different calicles described above are on different slopes of the surface, perhaps showing therein the influence of position on structure. (Cf. the two sides of the same specimen shown in Vol. II. Plate XXVII., "*Astræopora incrustans.*")

a. Zool. Dept. 93. 9. 1. 126.

43. **Goniopora China Sea** $_{(5)}$**4.** (Pl. V. fig. 6; Pl. XII. fig. 10.)

[S. side of Itu Aba, Tizard Bank, 2 fathoms, coll. Bassett-Smith; British Museum.]

Rhodarœa gracilis, Bassett-Smith (*non* M.-E. & H.), Ann. and Mag. Nat. Hist. (6°) vi. (1890) p. 457.

Description.—Corallum forms a stout almost columnar inverted cone, 14 cm. high, with smooth flattened convex top, 12 by 8 cm., and appearing as if built up of layers, owing to the

numbers of slightly projecting edges. In the earlier stages the stock appears to have rolled half over, and in the further growth to have bent up again into the vertical. The edge of the living layer seems to be about 4 cm. below the highest top.

The calicles very uniform in size (2 mm.) and shape, being neat circular punctures, 3–4 mm. deep. The walls are everywhere a beautiful but stout membranous lattice-work with large oval pores; the edges are irregularly denticulate according as new pores are just starting or are being arched over. The insides of the wall are roughened with low swellings, or round-topped projections, which are only seen to be regular septal striæ when looked at from above. They then appear as 24 rows of low, uniform, blunt teeth round the lower parts of the calicle, but not round the margin. Very deep down in the calicle the typical formula can be made out, the short tertiaries even bending round to fuse with the secondaries. From the central tangle a confused reticulum rises high up in the fossa, ending in a roughly stellate grouping of bent and twisted flakes. This stellate arrangement is only seen from above, and is due to the prominence of the secondaries. Only in the lateral calicles is the typical symmetrical rosette formed. In the deep calicles the pali do not always reach the same level of development. There is no central tubercle, but the tissue of the tangle rises to different heights in the centre of the ring of pali.

This is another of the forms in which the septa round the wall of the calicle are hardly visible, and a central rosette rises up from the columellar tangle instead. A comparison between this massive, more usual, form of *Goniopora* from only two fathoms, with the other three forms from the China Seas, all from great depths and all quite remarkable in their form-features, leads one to believe that the genus is still but little known. Our knowledge so far is mainly confined to shallow-water forms. The range of its variations will be immensely increased when a more thorough search has been made for it below tide-marks.

a. Zool. Dept. 89. 9. 24. 88.

There is a thin, apparently very young, encrusting colony of *Heliopora* attached to this specimen, which is interesting because the commensal worms which seem to be almost invariably associated with that coral are already present, thin as it is.

44. Goniopora China Sea $_{(5)}$5. (Pl. V. figs. 7 and 8; Pl. XII. fig. 11.)

[Macclesfield Bank, 32–42 fathoms, coll. Bassett-Smith; British Museum.]

Rhodarea? lagrenii? Bassett-Smith, Ann. and Mag. Nat. Hist., vi. (1890) p. 457.

Description.—The originally encrusting corallum appears to grow out laterally in long thin stems which periodically flatten slightly and fork. Those specimens from the greater depths seem to have thinner stems (6–10 mm.), which are then, owing to the size of the calicles, very angular. The living layer of the thicker (1·5 cm.) and more rounded stems is

3 cm. long, on the smaller stems 2 cm. The dead portions are swathed in a continuous pellicular epitheca like an Alveopore.

The calicles vary greatly in size from 3–6 mm., they are rounded only on the smoother parts of the stems (fig. 8). They are mostly drawn out of shape and angular (fig. 7). Of varying depths, but always shallow and gaping. The walls are a beautiful open reticulum of twisted flakes and threads, sometimes thick and smooth, at others delicate and frosted. The prominent septa take a very conspicuous part in the formation of the walls, and when the walls appear thick it is a rising of the upper edges of the septa which gives them this appearance; when the calicles are flush with the surface the wall is so thin that adjacent interseptal loculi communicate with one another (fig. 8). The septa are very conspicuous, the interseptal loculi being open and distinct even when the sides of the septa are frosted with points. The typical septal formula is visible to the naked eye; the tertiaries are well developed and bend sharply round almost at right angles, to fuse with the secondaries so as together to form a trident. The columellar tangle is large, very prominent, rising like a boss of elegant open reticulum in the gaping shallow calicles. From its surface the pali rise as parts of the reticulum (not as single threads or flakes), and their origin from the points of fusion can sometimes be seen by their outermost portions running back along the fusing septa.

The texture of the section of the branches shows an open, stout, coarse reticulum, without trace of regular trabeculæ.

There are four specimens of this coral: *a*, from 32 fathoms; *b*, from 40 fathoms; and *c* and *d*, from 42 fathoms. The variations in size of the calicles depends apparently upon the favourable conditions, for on *b* the dead portion of the stem shows some enormous calicles, while at its tip they are all smaller again. The thickness of the skeletal elements is also variable, and this makes the calicles look very different. The thin septa are frilled and frosted, while the thicker are smooth and wavy.

In the somewhat similar coral *Goniopora Great Barrier Reef 12*, p. 58 (Pl. III. figs. 7 and 8), called "*Rhodarœa fruticosa*" by Saville-Kent, the method of growth laterally from a small encrusting base is visible. This is not so clear in the present case, yet given this clue to the possible method of growth, the specimens seem to fall into line, although evidently more specialised for a branching growth. They all seem, for instance, as if they sloped at a low angle with the horizon, and the growing tip of the largest stem has even expanded as if repeating the explanate form. This kind of branching growth as a modification of an explanate colony by the formation of long lateral tongues, is seen again in the genus *Alveopora*. There is no resemblance between the Australian form and this coral, excepting in the general variation in the calicles which appear here as there circular on the smooth parts, and drawn out of shape on the branching tips.

a.	Zool. Dept. 93. 9. 1. 141.
b.	„ „ 89. 9. 24. 70.
c, *d*. (Parts of one and the same stock?)	„ „ 93. 9. 1. 224.

45. **Goniopora Java Sea (4)1.** (Cf. Pl. VIII. fig. 4.*)

[Billiton, coll. Dr. Bolsius; British Museum.]

A *Goniopora* showing the same type of growth as this specimen was named "*Goniopora Stokesi*, by Milne-Edwards and Haime, Ann. Sci. Nat., xvi. (1851) p. 41 (see next page).

Description.—Corallum a free hemispherical mass, ca. 5 cm. high and 8 cm. in diameter, with flattened base, the centre of which is often concave, and may show the wrinkled epitheca of the original colony. The living layer extends almost to the base, but there are usually a certain number of edges visible.

The calicles are large, 4 mm., polygonal, deep, ca. 7 mm. The walls rise to a great height with level top edges; they are thin, 0·5–0·75 mm., smooth and lattice-like just below their margins, with toothed edges, while in shallower calicles at the edge of the living layer they are thick and reticular. The septa are in three cycles, very thin, and appearing gradually at some distance (2–3 mm.) below the top of the wall, first as minute but not sharply pointed teeth; their edges describe concave curves before joining the columella. The septal formula appears to be complete and typical, the septa being soon lost in the network of the columella. The columellar tangle is an irregular convex mass of compact reticulum composed of delicate flakes (cf. the thin septa). Here and there, especially in the shallower calicles round the edge, it shows signs of a stellate arrangement of its reticular mass, the rays corresponding with the pali or points of fusion of the septa.

In texture, there is a great contrast between the solid walls which gradually thicken from their edges downwards and the more delicate intracalicular skeleton built up of the thin septa and the large columellar tangle. Tabulæ run through the corallum and are continuous with the epitheca supporting the edges.

As noted in the Introduction, p. 24, the hemispherical growth-form was one of the simplest modifications of the primitive form of the colony, being obviously due to an increase in depth of the central calicles.

This coral grows free, the parent having attached itself to some perishable material or to a small loose object. *G. Maldives 4*, which is of the same type, see next page (δ), also grows free. In this Billiton coral, however, the base remains flat and the latest colony completely or almost completely covers all that went before it.

There are two specimens from Billiton, one in spirit showing the 24 tentacles compactly crowded in the bases of the calicles.

a. (Rolled and worn).	Zool. Dept. 83. 7. 24. 102.
b. (In spirit).	„ „ 83. 7. 27. 7.

* The figure refers to *a* on next page.

Appendix to Goniopora Java Sea (4)1.

Forms from other localities with essentially the same method of growth, but showing variations.

(*α*) (Pl. VIII. fig. 4.) There is a perfectly symmetrical hemisphere in the National Collection (see p. 154), from some unknown locality, showing the same characters, but with calicles much more uniform in size, nearly 5 mm. across, very deep, and with thicker walls, the edges of which are flush with the surface. The regularity of the calicles and the number of conical depressions of young buds in the angles are to be noted.

(*β*) There is a specimen in the Paris Museum which was named by Milne-Edwards and Haime "G. Stokesi." It is also without known locality. Calicles 5–6 mm. across, 6–7 deep, sometimes a fourth cycle of septa.

(*γ*) There is a specimen, *G. Singapore 6*, in the Cambridge University Museum, which shows a kind of transition between this form and the straight columnar method of growth, cf. Dana's "*G. columna*," from Fiji. Its contour is oval, and the successive growths tend to rise like tight-fitting caps without very much increase in size, the uppermost merely bulging irregularly. The calicles are essentially of the same build as those above described, and average about 4 mm., but they are not quite so deep; the delicate frilled septa rise higher, that is, nearly to the top of the wall, and the walls are very thin, but show a tendency to thicken in the angles. Their upper edges are very irregular and rise to different levels.

(*δ*) The Maldive corals (Pl. VII. fig. 6 and Pl. XIII. fig. 9) of the same type show interesting differences. They appear to grow on soft mud, into which the younger basal parts sink, and the stocks are all built up of a series like rolls of coins increasing in size, and the series is usually bent. The calicles are large, up to 6 mm. (Pl. VII. fig. 6), gaping, angular and shallow, sometimes not more than 3 mm. deep. The walls are not thick, but are friable, delicately frilled and zigzag, and very perforate; the top edges rise to very different levels, the angles, with young buds, often shooting up. The frilled septa rise right to the top of the walls, and, though narrow, are very conspicuous toothed ridges. Usually in the large calicles more than 24 septa. The typical formula is difficult to make out, although fusions into groups of 3 and 4 can be seen (cf. fig. 6, Pl. VII.). The columellar tangle is a close mass of fine curling flakes, and grows so straggled about the base of the calicle (as it does, though in a lesser degree, in the preceding forms) that it looks like a pathological proliferation of the skeleton running up the edges of the septa and sometimes involving groups of septa. In doing this it may assume a stellate arrangement, which only approaches symmetry in the shallower lateral calicles where the columella has become an immense, convex, nearly solid mass.

See further on these corals under the heading *Goniopora Maldives 4*, p. 89.

It is thus seen that the differences between these corals are so great, that to class them under one heading simply because of the similarity of growth means no more than that you give a name to the type of growth. This name would have to be, according to rule, "*G. Stokesi*." This is useful, but the help which it gives towards a natural classification is limited.

46. Goniopora Java Sea (4)2.

[Valley of the Tji-lanang (Gunung Sela), not far from Liotjitjangkang, Rongga District (Upper Miocene), ? Museum.]

Litharæa affinis, Reuss, Über foss. Korallen Java: Reise Österr-Fregatte Novara, ii. (1866) p. 175, pl. ii. fig. 5*a*, *b*, *c*.

Description.—The corallum forms small mounds with convex surfaces.

Calicles 4–5 mm. across, shallow, "polygonal" (circular in the figures). Walls broad, flat, rather closely reticular, smooth nodulated threads and somewhat jagged surface ("mit spitzigen Höckerchen regellos besetzt"). Septa normally 24, of uniform thickness from the periphery, wavy, almost regularly fenestrated, and united by synapticulæ so that the septal apparatus often appears like a network with rounded meshes. The septal formula is typical; this is not clear from the figures, but the text distinctly states that the primaries and secondaries are nearly equal in size, but the tertiaries are short and bend round to fuse with the secondaries about half-way between the wall and the columella.

The columellar tangle is large and reticular, but not very sharply marked off from the reticulum above described as due to the joining of the wavy septa by synapticulæ.

Two magnified figures are given, that of the surface, 5*b*, agrees with 5*a* in showing broad reticular walls almost half the diameter of the calicle, but in fig. 5*c*, which shows a specimen worn down, the walls are much thinner.

The large columellar tangles, indefinitely increased by the addition of synapticulæ, are an interesting feature.

Two other fossil Gonioporas occur in the same part of Java, viz. the "*Porites incrassata*" of Reuss (*l.c.*, see next heading) and the "*Litharæa astræoides*" of Martin ('Die Tertiärschichten auf Java' (1880), p. 148). Martin points out some of the differences between his "Astræoides" and the form now under discussion. We may note in the former the absence of synapticulæ, the smaller calicles, and the non-fusion of the septa of the second and third cycles. To these may be added the very sharp circumscription of the columellar tangle. Martin's last figure, however, which shows this (see his Pl. XXVI. fig. 9) may be purely diagrammatic.

Reuss called attention to the resemblance between this form and the well-known English Eocene (Bracklesham Bay) form "*Litharæa Websteri*," M.-E. & H., but the skeleton of the former is altogether stouter. The Bracklesham Bay coral has a very variable skeleton, but it is usually delicate, and the septa are not wavy nor is there any conspicuous development of synapticulæ, at least sufficient to make the whole intracalicular skeleton a reticulum, the columella being only its central concentration (see p. 147).

47. Goniopora Java Sea (4)3.

[From the same locality and formation as *G. Java* (4)2.]

Porites incrassata, Reuss, Über foss. Korallen Java: Reise Österr. Fregatte Novara, ii. (1866) p. 174, pl. ii. fig. 4.

Description.—Corallum of unknown growth-form. The only specimen was a fragment of irregular outline, with what appears, from the figures, to be a convex surface; it seems possible to consider the specimen as a typical plano-convex corallum with the edges broken.

Calicles 4 mm. in diameter, polygonal, very shallow, without sharply raised walls, and indistinctly separated from one another [the large meshes of the flat reticular wall often not shut off from the interseptal loculi]. "8–18" conspicuous septa, thinning away towards the centre. The primaries, and a few of the secondaries, reach the centre, the rest fusing with those next them, "so that some of them appear branching"; irregularly perforate, and covered with small pointed granules. 6–8 rounded granules as pali surround a small columellar tubercle.

In this interesting form we see all stages in the process of the fusing of septa nearer and nearer to the wall, till some of the pairs seem to be single septa with two abutments on the wall. This is what we find in the specimens described on p. 140, in which the process was so far gone that they might easily be mistaken for transition forms between *Goniopora* and *Porites*.

On this subject see observations in the Introduction, p. 21.

48. Goniopora Java Sea (4)4.

[West of Liotjitjangkang, Rongga district (Upper Miocene), ? Leyden Museum.]

Litharæa astræoides Martin, Die Tertiärschichten auf Java, (1880) pl. xxv. 14, 15, and xxvi. 9.

Description.—Corallum convex, gibbous.

Calicles, from subpolygonal to subcircular, from 2 to nearly 3 mm. across, moderately deepened; the wall a somewhat thickened granular reticulum ("schwammig"), the "well-developed" septa in three cycles, the third being generally incomplete; almost all reach the large reticular columellar tangle. They are very lamellate, with few pores, except near the inner edges where they meet the columella, and with granulated sides. A few cases of septa fusing near the wall are seen. The upper edges of the septa are denticulate. The surface of the columella shows signs of forming paliform prominences.

The author says that this coral differs from *Litharæa affinis* Reuss (see *Goniopora Java Sea 2*), in that the calicles are smaller, the granules at the sides of the septa are smaller and do not unite across the interseptal loculi, and the septa of the second and third cycles do not typically fuse together. A further difference is pointed out on p. 77. Unfortunately the photographs given by Martin are not very clear, and his drawing on pl. xxvi. fig. 9 is rather too diagrammatic.

49. Goniopora Singapore (6)1. (Pl. V. fig. 9; Pl. XII. fig. 12.)

[Probably Rabbit Island, Singapore; British Museum.)

Rhodarœa lugrenœi, Brüggemann (*non* M.-E. & H.) Abh. Nat. Ver. Bremen, v. (1878) p. 547 (see p. 70).

Description.—Corallum a large, low, branching tuft, 25 cm. high, stems round and thick, 2–3 cm. and dividing about every 2–3 cm. The short, thick, round-topped branchlets with a strong tendency to curve. They frequently flatten before redividing. The living layer, 10–12 cm. deep. No pellicular epitheca covers the dead basal parts.

Calicles vary greatly in size, average 3 mm. (with double calicles 4–5 mm.); everywhere shallow and open, but deepest round the growing tips; irregularly polygonal or angular. The walls are very irregular and rise to different heights, often not even straight; either thin, fenestrated, and sharp with serrated edges, or thick and solid-looking, and running into irregular angles and points, with hardly any trace of symmetry, except over older basal portions, where the edges are regularly serrated by indications of septa. The septa are very thin, and appear thread-like from above, bent and curved, and fusing irregularly, and with hardly any visible radial symmetry. They seem to start at any angle from the walls, and form an open irregular network. The tertiaries can be seen most frequently bending round in quadrants to fuse with the secondaries. In the calicles at the tips the columellar tangle is hardly differentiated from the light open reticular fusions of the septa, but it gradually becomes more and more pronounced, until in a lateral calicle (fig. 9) it is a large solid plate, gradually closing the open rounded or angular interseptal loculi till they are a mere ring of small holes close round the wall. The radial symmetry of the calicle becomes most pronounced upon this columella. At first thin, ragged, and irregular pali appear, and gradually thicken into stout coarse knobs running outwards along the septa towards the wall. The star-like symmetry seen by the naked eye tends to vanish when it is examined with a pocket-lens.

In sections of the branches the axis is seen to be an open longitudinally streaming flaky reticulum, and this comes to the surface at the rounded tips of the branches. Round this axial reticulum the radial trabeculæ are fairly distinct. Delicate tabulæ run close under the surface, showing that the calicles are shallow.

Some light may be thrown upon the exact locality of the coral from the fact that there is a fragment of a dead base of exactly the same kind of stock in the Cambridge Museum (coll. Bedford and Lanchester) with a label which runs, "Rabbit Island, Raffles Lighthouse, outer edge of reef; not many corals."

There are five specimens (parts of two stocks) in the National Collection. They are interesting as being more nearly dendroid than any other known *Goniopora*, and, moreover, the growth-form cannot in this case be traced to the bending up and curling round of tongues of thin explanate growths such as appears to be the case in the other two known branching tufts described above (see *G. Great Barrier Reef 12* and *G. China Sea 5*). I think this growth is a further development of the forms described under the next heading, that is, from the columnar growth-form, see Diagram E, fig. 2, p. 24, of the Introduction.

The shallow calicles with obscured radial symmetry seem to be common to other Singapore forms. See the observations on p. 84.

a. Zool. Dept. 78. 4. 1. 9.
b, *c*. Parts of *a*.
d. ,, ,, 78. 4. 1. 8.
e. Part of *d*.

Purchased from Herr Gustav Schneider of Basle.

50. **Goniopora Singapore** $_{(6)}$**2**. (Pl. VI. figs. 1 and 2; Pl. XII. fig. 13.)

[Singapore; British Museum.]

Goniopora malaccensis, Brüggemann (*partim*), Abh. Nat. Ver. Bremen, v. (1878) p. 548.

Description.—Corallum columnar and flattened laterally, with smooth vertical sides and evenly rounded tops. The columns fork to form irregular clusters of smaller columns, which may be alive for nearly 16 cm. on the outer but only 6–7 on the inner surfaces; a delicate pellicular epitheca appears at intervals. The dead lower portion of the outer surface is frequently grown over by a descending edge.

Calicles irregular in shape, angular and subcircular, from 2–2·5 mm. diameter, uniformly shallow. The walls, when simple, are very perforate, often hardly straight, and with a distinct close but irregular zigzag (fig. 1). Where the walls are thicker, e.g. at the angles, and irregularly along single sides of the calicles (fig. 2), they are neatly reticular. The 24 septa are rough or jagged processes, symmetrically and uniformly arranged in the thick-walled calicles, at least round the walls, but as so many ragged points on the younger calicles (fig. 1). The typical septal formula can be made out where the septa unite with the large columellar tangle, which fills the floor of the more regular calicles as an open granular reticulum. But in the younger calicles the whole skeleton is a light open reticulum of thin threads and flakes with large meshes, and in this it is impossible to make out even any radial symmetry (fig. 1). In this part the meshes of the columellar tangle are as large as the interseptal loculi, and the former is mainly differentiated by the flaky character of its skeletal elements. From the surface of the more differentiated columellar tangle an arrangement of twisted branching threads, visible to the naked eye, represents the pali, but their symmetry largely disappears under the pocket-lens.

This coral, and the next, while they were in the possession of Herr Gustav Schneider, of Basle, were classed together by Brüggemann as a new species, "*Goniopora malaccensis.*" On going over them again, however, he changed his mind, for in his manuscript Catalogue of the British Museum Corals, p. 394, he mentioned only one, viz. *Goniopora Singapore 3*, as his *Goniopora malaccensis.* But his original diagnosis was based upon both specimens. This is another instance of the confusion that arises from the obligation to establish "species" with inadequate data.

The two corals can easily be compared by reference to the figs. on Pl. VI.: cf. figs. 1–2 with figs. 3–4. The pronounced reticular texture, the large number of thin, distinct, symmetrically arranged septa, and the prominent delicately reticular columellar tangle of this coral contrast with the few thick coarse septa ending squarely and bluntly round a fossa, sometimes like a ring of paliform plates, of the next coral. Nothing but the exigencies of "species making" could have induced so distinguished a naturalist as Brüggemann to class the two together.

A comparison of Pl. XII. fig. 13 with fig. 1 on Pl. XIII. shows also the difference in their growth-forms.

a. Zool. Dept. 78. 4. 1. 5.
Purchased from Herr Gustav Schneider, in Basle.

51. Goniopora Singapore (6)3. (Pl. VI. figs. 3 and 4; Pl. XIII. fig. 1.)

[Singapore; British Museum.]

Goniopora malaccensis, Brüggemann, MS. Catalogue, and (*partim*) Abh. Nat. Ver. Bremen, v. p. 348. [Cf. *G. Singapore 2.*]

Description.—Corallum rises into an erect column, which thickens evenly as it rises; with smooth slightly convex top and smooth sides, frequently sloping or curving outwards as they rise. Oval or triangular in cross section, in the latter case with the angles rounded. The column appears to grow some 10 cm. high and 7–8 across the top, after which a cluster of new columns grows upon the top. The living layer extends about 3·5 cm. down the sides. No continuous epithecal film.

Calicles irregularly polygonal, 2 mm. across, except where lengthened out to 3 mm. on the sides, where the calicles strive to turn upwards; sometimes deep and funnel-shaped—e. g. on the top, where they open in a streaming mass of nearly lamellate reticulum. On the top (fig. 3) the walls are formed of this reticulum, and are rather more delicate in texture than are the well-developed septa. On the sides the walls are sharper, irregular and mostly simple, neither straight nor regularly wavy, but crooked, jagged or granulated, the lower one frequently steep, the upper one sloping upwards.

The septa, usually in two cycles, stout and conspicuous, projecting just below the margin and then bending down suddenly into the fossa. This bend becomes a sharp rising point in the shallow calicles, and represents a palus, but on the deep calicles it is rounded off. Tertiaries may appear in the lateral calicles. Below this ring of pali, which surrounds a fossa, a reticular tangle occurs, but it is hardly conspicuous as a columella; though in the lateral calicles it

becomes flat and flaky. The septa of the upper halves of the lateral calicles are longer than those of the lower, and their edges often show two or three granular swellings. The fossa is necessarily eccentric in such cases.

In section the reticulum is dense, but the calicles are visible from the radial arrangement of their 12 thick lamellate septa and large interseptal loculi.

This was one of two corals originally united in Brüggemann's "species" *G. malaccensis*, and was afterwards selected as the type of the "species," although the description was based upon them both (see last heading).

The calicles in this coral in their more important structural features somewhat resemble those of other forms which also grow as triangular flat-sided columns swelling as they rise, and with the skeletal elements consisting of an expanding sheaf of lamellæ which appears at the top as a ragged reticulum (see *G. Maldives 2* and *3*, Pl. VII. figs. 2 and 4, *G. Red Sea 1*, Pl. VIII. fig. 1, and an account of the expanding sheaf method of growth, Introduction. p. 26). The calicles are here, however, very small (2 mm. and less), and very variable in depth. There are, as a rule, only two cycles of septa, of which one, presumably, the primary is conspicuous, jutting out prominently round a central fossa as stout lamellæ, when seen from above, but deeply notched when seen from the side.

a. Zool. Dept. 78. 4. 1. 4.

52. **Goniopora Singapore** $_{(6)}$**4**. (Pl. VI. figs. 5 and 6; Pl. XIII. fig. 2.)

[? Exact locality, coll. Bedford and Lanchester; Cambridge University Museum; duplicate in British Museum.]

Description.—Corallum forms lobate pear-shaped masses. The thickness of the base seems to depend upon the nature of the object to which it is attached. The uppermost surface may be coarsely divided by wide valleys into three to four lobes. The living layer, which bulges out laterally, is 4 cm. deep.

Calicles, on account of the large number of young buds in these swelling knobs, very variable in size up to 4 mm.; deep, open, angular, and drawn out of shape on the sides; nearly circular when opening in the lamellate reticulum on the top. The walls show a strong tendency to be reticular (fig. 6); they can however be very thin where the calicles are crowded, only in the wall-angles are they then reticular, and these angles may rise like points above a general level. Here and there additional thin synapticulæ unite the septa and turn the thin walls into a very porous delicate spiky reticulum. The septa are numerous and conspicuous as thin rows of teeth, they descend vertically and curve round to lose themselves in the large columellar tangle. Their radial symmetry is frequently obscured and the typical formula is seldom complete, and always difficult to unravel. The columellar tangle is very large and spongy, with round perforations in a flaky reticulum, and only in some of the shallowest lateral calicles showing signs of pali-form elevations.

There are patches on this coral showing the same upwardly streaming lamellate reticulum as was noted in the last coral. In the calicles opening in such patches we see a proliferation of the septa as delicate, wavy, highly perforated plates, filling up the calicle flush with the surface (fig. 5). The position of these patches at the tops or points of bulging processes, taken together with the fact that this proliferation of lamellate septa is characteristic of the growing tops of other Gonioporas mentioned under last heading, leads us to think that these are centres of rapid growth. But at the same time they look in this case like places where normal growth has been hindered by proximity to some foreign object.

There are two specimens of this coral. A large mass growing on the edge of a dead *Agaricia*, with lobes swelling out in all directions. This is in the Cambridge University Museum, while the smaller duplicate is in the British Museum. The smaller specimen, figured on Pl. XIII., is pear-shaped, with a stalk-like base.

a. Presented by Mus. Univ. Camb. Zool. Dept. 1902. 9. 9. 7.

A larger specimen is in the University Museum at Cambridge.

53. Goniopora Singapore (6)5. (Pl. VI. figs. 7 and 8; Pl. XIII. fig. 3.)

["Rabbit Island, Raffles Lighthouse, outer part of reef, very narrow, and not very flourishing," coll. Bedford and Lanchester; Cambridge University Museum, and duplicate in British Museum.]

Description.—The corallum rises as an elongated swelling knob, which divides into fresh swelling knobs of different sizes, the whole resulting in thick branching clusters; the terminals being shaped according as there is room for them to grow. The outermost knobs tend to curve inwards. The basal stalk is about 3 cm. thick, the stems of the topmost lobes somewhat thicker. The living layer is 7–8 cm. deep on the outer surfaces, less on the inner lobes.

Calicles angular, open, very shallow, conical and deep only on growing tips, variable in size between 2 and 3 mm. The walls at the top consist of a fine, very angular filamentous matted reticulum, in which the buds develop as breaks. Round the topmost area the calicle walls are thin, perforated, and very irregularly zigzag (fig. 7). Still lower down the nodes of the wall reticulum swell into large solid granules, so that the walls become ultimately low irregular rows of closely packed grains, making them look thick and solid; only very low down do the granules become more regularly arranged like the tops of radiating septa (fig. 8). The septal striæ on the walls are mostly obscured by the fact that the septal teeth are irregular and bent about, meeting and fusing, and forming a kind of nap on the walls. Where lower down they meet the columella their radial symmetry is lost (see fig. 7). The centre of the calicle is occupied by the columellar tangle, which on the top is an open filamentous reticulum, solidifies laterally into a mass of large granules, at first straggling, but gradually becoming compact (fig. 8). This large solid columella is attached to the walls by short threads, which are the remains of the septa with here a slightly recovered radial symmetry. From the surface of the columellar tangle knobs of branching threads arise to form parts of a ring of pali.

The specimen in the Cambridge Museum is a fair-sized stock (broken into three fragments, which fit together). The specimen in the British Museum shows all the important characters.

One is at once struck by the general similarity between the shallow calicles with the low thick wall, like a network on the surface, of all these columnar and branching forms from Singapore. But similar as they are to the naked eye, the differences when closely examined (cf. the magnified figures of the calicles, Pl. VI. figs. 1–2 with 3 and 4, and these again with 7–8, and with fig. 9, Pl. V.), coupled with the differences in growth-form (cf. Pl. XII. figs. 12, 13, and Pl. XIII. figs. 1 and 3), are too great for them to be included under one and the same heading. See the observations on the Singapore forms.

a. Presented by the Cambridge Museum. Zool. Dept. 1902. 9. 9. 8.

There is another specimen in the University Museum at Cambridge.

54. Goniopora Singapore . (Pl. XIII. fig. 4.)

[? Exact locality, coll. Bedford and Lanchester; Cambridge University Museum.]

This coral has been already briefly described (see γ p. 76). It shows almost the same method of growth as *G. Java Sea 1*, which see for description and illustrations. Cf. also the observations on the variations in structure shown by the Singapore specimens below. The coral is not perfectly hemispherical, but slightly compressed laterally, and with swollen top.

Observations on the Singapore Forms.

The series from this locality provide remarkable evidence for the interdependence of growth-form and the type of calicle.

The series of Diagrams on p. 24 (Introduction) will serve to explain the conditions. The hemispherical stock *G. Singapore 6* has deep calicles everywhere except round the base. In the pear-shaped stocks the zone of shallow calicles with central rosettes extends still further, until in the columnar *G. Singapore 2* and in the finely branching *G. Singapore 1* the deep calicles are confined entirely to the growing points. The deep calicles never have central rosettes of pali, which are typical of shallow lateral calicles.

We have, unfortunately, no data for correlating any other characters of the calicles which bear a superficial resemblance to one another through all the series with their special growth-forms. We may, however, note that the light, open, reticular calicles (Pl. VI. figs. 1 and 2) belong to the form which, from the size of the columns and the extent of the living layer, seems to have grown very rapidly, while the calicles (Pl. VI. figs. 7 and 8), which are composed of solid granules, belong to a totally different form in which upward growth seems to have been slow.

These facts are sufficient to show that the representatives of the genus in any locality may show series of transitions, each characterised by a group of obviously interdependent variations. If this is so, it is enough to shake our belief in the stability of any single character other than those which mark the genus. Until we have more evidence, it is possible

to hold that one common parent form might be able to produce all the forms displayed by the genus in any particular locality, the ultimate differences, no matter how great they appear, being due entirely to the start made by that parent polyp in one direction or another. The nature of the start may depend upon the character of the environment in which the larva becomes sessile. At the present, however, our belief in such unlimited plasticity requires restraining until we understand better what heredity means. The fact that the parent form repeats the generic characters reveals the presence of that force beyond question. What may, however, be open to question is whether any of the derived forms are stable enough to have acquired enough of this force to be able to repeat themselves indefinitely from within, and independently of the environment. The evidence so far seems to be that such force of heredity *is* acquired by the derived forms. There are specimens in the Museum showing two very distinct forms of the genus *Turbinaria* growing side by side upon the same pearl shell.

Group IV.—INDIAN OCEAN.

Containing descriptions or records of Gonioporæ from Ceylon (1); *Maldives* (1–4); *Mauritius* (1); *Seychelles* (1).

55. **Goniopora Ceylon*** (1)**1.** (Pl. VI. fig. 9; Pl. XIII. fig. 5.)

[Ramesvaram, Gulf of Manaar, coll. Thurston; British Museum.]

Description.—Corallum rises into columns 15 cm. high and more, with smooth, rounded, very slightly bulging tops, hence only gradually thickening as they rise. The sides may be rounded, or flattened, broad and wavy, 6–7 cm. thick. Free edge formation is not very conspicuous. The living layer descends some 4–5 cm. The epitheca does not form a continuous pellicle, but is in wrinkled bands running round the small edges.

The calicles are large (4–5 mm.), open, conical, and very conspicuous, with great numbers of buds of all sizes in the angles. At the summit, where growth is most active, the calicles are generally smaller and some 4 mm. deep; at the sides (fig. 9) they are larger and more open, and gradually diminish to 2 mm. deep or less. The wall is very thin, often incomplete, hence perforate, and zigzag, though owing to the thickness of the septal laminæ, which may be almost described as exsert, at first sight it may appear thick. Seen from above the septa are sharply wedge-shaped, thick, and very slightly differentiated where they join the walls. Most show a tendency to a spiral twist. Their edges as they descend are conspicuously and regularly denticulate, the perforations usually being in vertical series. The primaries project further in than the rest, and their edges become thick and coarse. The complete formula is

* It has been pointed out to me that Madras would have been a better district name, but it was too late to alter it.

recognisable in the larger calicles, the tertiaries bending sharply round to fuse with the secondaries. The columellar tangle is usually obscured by the thicker granules from the edges of the larger septa, but under these its threads are seen to be thinner, like the edges of the tertiaries. Except for the thickening granules of the large septa there is no rosette formation. In sections the wall is seen as a thin membrane, and the interseptal loculi to be large and conspicuous. Tabulæ appear at regular intervals. The coral is massive and heavy.

The growth-form of this coral immediately recalls the specimens from Fiji, called by Dana "*Goniopora columna*." But the calicles differ in almost every respect (see p. 43). A fictitious resemblance is given to the two by the dead surface in both being covered with small worm-tubes, as shown in Dana's figure. There are also corals, shells, oysters, and balanids on these specimens.

This columnar growth-form may be reached along several different lines of development; in this case we have the sides nearly smooth, and the different growth periods are only betrayed by the ribands of epitheca.

The spiral twisting of the septa is of interest, but the only clue to its cause is seen in the lateral calicles, where the septa, when they reach the wall, tend to bend round, so as all to run out as parallel striæ to the edge of the living colony. This twist seems to persist in the calicles long after they have left the edge, and even in calicles which never formed any part of the edge, but budded on the summit. The twisting of the septa is a common phenomenon among the Stony Corals. Attention was called to it in *Turbinaria*, see Vol. II. p. 13.

a. (Thick compressed column.) Zool. Dept. 88. 11. 25. 19.

b. (Round column, and showing what appears to have been an irregular start upon an explanate *Montipora*.) „ „ 88. 11. 25. 15.

56. **Goniopora Maldives (4)1**. (Pl. VII. fig. 1; Pl. XIII. fig. 6.)

[Addu, 32 fathoms, coll. Gardiner; Cambridge University Museum.]

Description.—Corallum forms groups of thin encrusting colonies, not however always closely adhering, with rounded or straggling outline, and with smooth slightly convex upper surfaces. The group may be formed by an original colony dividing up, each continuing to expand and divide, covering over former dead colonies, until a rounded mass, full of irregular hollows opening in spaces between successive growths, is built up. The edges of the colonies are sharp and frequently with slightly projecting epitheca.

The calicles vary from 2 to 3 mm., are almost obsolete, and, as is usual in these encrusting forms, appear to be built of radially arranged granules (cf. figures and descriptions of *Goniopora N.W. Australia 2*, p. 60, *G. China Sea 2*, p. 71). They show the typical septal formula, and the granules which seem to form the septa increase in size near the wall. Considerable variation occurs in the calicles of the different colonies, variations probably due to differences of position. In some, which appear to have been low down near the under

parts of the mass, the surface is quite smooth, the walls being not raised at all; in others the peripheral septal granules get very large, coarse and crowded, and gradually rise into a slight thick wall-ridge; in others, again, the wall-ridge rises rather suddenly, and the wall is thick, smooth-topped, and nearly flat, its component granules being large and crowded. The typical palic formula can be made out, though somewhat obscured. It consists of the rather larger frosted granules rising where the septa fuse together. The directive septa with the central granule frequently divide the calicles conspicuously into symmetrical halves. Fig. 1 shows the calicles of a stock with walls slightly raised.

The method of growth here is peculiar. We have thin encrusting Goniopores in *G. China Sea 2* and *3*, and also *Goniopora N.W. Australia 2* and *3*, and they all show with slight variations the same type of calicle, the septa appearing to be rows of granules.

In the present case the method of growth is peculiar, for the colonies keep throughout the same smooth curvature of surface. This, as the colonies break up, necessarily results in a lobulate reniform mass, all the lobules showing a similar curvature.

We are here again confronted with the problem as to the relation of growth-form to the shape of the calicle. Did the shallow calicle with the rows of granules for septa start this encrusting form of colony, or did the early form in which the colony was able to grow fix the character of the calicles? It is worth noting that on this specimen the calicles vary according to the position on the stock of the colonies to which they respectively belong.

The dimensions of the single specimen are 15 cm. long and 8–9 high, and there are twelve colonies on it of all sizes from 1·5 cm. in diameter to long straggling strips 8 cm. long.

57. Goniopora Maldives $_{(4)}$2. (Pl. VII. figs. 2 and 3; Pl. XIII. fig. 7.)

[Hululu, coll. Gardiner; Cambridge University Museum and British Museum.]

Description.—Corallum rises into short, thick, angular, rather flat-topped columns, slowly increasing in thickness as they rise, and with smooth flattened sides. The living layer descends to various depths, from 5–6 cm., sometimes even reaching 9 cm.

The calicles on the flattened, slightly convex and irregularly wavy top (fig. 2), are all of the same pattern, some 3 mm. across, 2–3 mm. deep, conical, crowded, but all as if breaking through an extremely friable, ragged, laminate reticulum. The walls are thin and membranous, very porous, with large openings, and, consequently, frequently incomplete at the edges; they are hardly conspicuous enough to show any definite zigzag or straight course of their own. The laminate septa form the chief element in the walls, and are so incised and porous as to appear quite ragged, while the obscuration of their radial symmetry adds to this effect. They begin to project in irregular numbers just below the margin, but their deeply incised edges merely send sharp or forking tongues into the fossa, which there twist and bend about, meeting and fusing deep down in the calicle.

The calicles at the sides have a very different character (fig. 3), which reaches a climax on the lowest strips of the living layer, where they are frequently 5 mm. across, almost flush

with the surface. The septa are rows of granules, which run over the broad flat walls, striating them transversely. The typical septal formula may be here obscured by there being as many as 30 septa. All transition stages can be seen between these two extremes of calicle formation.

Remarkable, and hardly due to accident, are the large irregular interseptal loculi (see fig. 3), as if a few septa here and there round the calicle had been dropped out, or, rather, never developed further than as wall granules. These gaps add to the difficulty of discovering the septal formula in a coral in which the septa in other respects are specially conspicuous.

On this form of growth, in which the skeletal elements seem to consist of an expanding sheaf of laminæ, we have already commented (see Introduction, p. 26, also Table III. p. 171). In all cases in which it is found we have again the same kind of calicles tending to develop to similar extremes. In no other form, however, does the living layer extend down so far, and, consequently, in no other form do the lateral calicles become so pronounced.

The large interseptal gaps might easily be thought to be accidental, but they occur not only in these specimens and in nearly all their calicles, but also in the two related forms, the description of which follows next.

The figures are all from the specimen in the British Museum.

a. Presented by the Cambridge University Museum. Zool. Dept. 1902. 9. 9. 9.

A larger specimen is in the University Museum, Cambridge.

In addition to these there is a small fragment (from the "Maldive Islands" and belonging to the same Collection) which is probably part of the top of a smaller column with smaller calicles. But being only a fragment, and showing such structural similarity, I place it here provisionally as *b*. The real growth-form is not known, and I rely upon the tendency to raggedness and general similarity to the specimens of *G. Maldives 2* for the above statement. The calicles (2 mm.) look deeper and more cylindrical. The walls are not so ragged, and either membranous or else reticular (cf. next specimen), and the part which the septa play in their formation is obscured. The septa, which do not appear in the walls, are very conspicuous in the calicle, and project as 5 to 8 very thin perforate plates, some of them nearly to the centre. Their numbers and direction are irregular, and traces appear of the large interseptal gaps described for specimen *a* and for that in the Cambridge Museum.

b. Zool. Dept. 1902. 9. 9. 10.

This form seems to lead on to the next coral.

58. Goniopora Maldives (4)3. (Pl. VII. figs. 4 and 5; Pl. XIII. fig. 8.)

[Island not named, coll. Gardiner; Cambridge University Museum.]

Description.—Corallum an irregular long-oval nodule, flat topped and with sides bulging over the base of attachment, to which the edge of the living layer closely adheres. A pellicular epitheca covers over the slight edge formations.

Calicles about 2·5 mm., ill defined as deep irregular holes in a delicate friable reticulum. On the uppermost surface they are often hardly distinguishable, there being frequently no

radially disposed parts to differentiate them from the thick raggedly reticular walls. Seen from above the skeleton appears to be a delicate, friable, filamentous sponge-work, but viewed slantingly the reticulum is seen to be composed of a sheaf of very thin vertical and ragged flakes (fig. 4). Here and there these are disposed as radial septa, but much bent and twisted; in the majority of cases, as stated, the bending and twisting is so great that the radial symmetry is completely obscured. At the sides the walls appear better defined, the symmetry of the calicle can here and there be made out, and the septa slope inwards as rows of long delicate teeth. The laminate character of the reticulum may here be almost entirely lost, and the skeletal elements appear wholly filamentous. Indeed, when the lateral calicles become very shallow the whole skeleton is an elegant filamentous reticulum, walls and internal skeleton alike, with hardly any appearance of radial septal plates. All the ordinary lateral calicles, however, show distinct traces of lamination when carefully examined (fig. 5).

In this coral, of which there is unfortunately only one specimen known, the ragged top has melted down into a reticulum with more complete loss of radial symmetry than was seen in the last coral. The specimen described as *G. Maldives 2, b*, seems to lead on to it, except that there at least some of the septa persist as conspicuous radial structures within the fossa. The three forms are clearly allied, but we want a larger series before we can arrange them in any developmental order. All we can say at present is that this last form described is the most specialised in the obscuration of the radial septa by the thickening of the laminate wall-reticulum.

The growth-form is quite typical, the top surface consisting of a sheaf of laminate septa twisted and crushed together, and all with toothed edges; the lateral surfaces of the stock look in parts as if composed solely of these teeth. I do not say that this description is a true account of the morphology; if it is, it requires explaining. I am more inclined to regard the purely filamentous reticulum of these parts as abnormal, and due to the proximity of foreign bodies, while the filamentous texture of the ordinary lateral calicles may be regarded as due to their having retained more nearly the primitive characters of the genus; in each case they show some traces of the peculiar modification of this form, viz. the lamination of the skeletal texture.

Cambridge University Museum.

The fragment *b* of the last type above alluded to is in the British Museum, and being structurally a transitional form (though with larger calicles) will help to illustrate the peculiarities of this coral.

59. **Goniopora Maldives** $_{(4)}$**4.** (Pl. VII. fig. 6; Pl. XIII. fig. 9.)

[Felulu (25–28 fathoms), Nilandu (24 fathoms), Suvadiva (42 fathoms), Kolumadulu (40–45 fathoms), coll. J. Stanley Gardiner; Cambridge University and British Museums.]

Description.—Corallum built up of successive hemispherical, almost columnar, caps fitting imperfectly into one another. The youngest from 1·5 to 2 cm. in diameter, with epitheca

flattened out upon a soft yielding substratum (sand or mud). The whole stock consisting of a gradually diminishing series is bent about irregularly, apparently as the lower ones sank regularly or irregularly into the substratum.

The calicles are large, 6–7 mm. in diameter, very angular, and rather gaping (fig. 6), of varying depths. Walls most frequently straight, thin, membranous, with great numbers of minute perforations. Here and there the angles thicken into a stout but foaming reticulum. The top edges of the walls rise to very different heights, making the whole surface not seldom very irregular. The septa, as a rule, show the typical formula, and run to various heights up the wall, sometimes ending in straight symmetrical rows of close delicate teeth. They are most pronounced and stoutest as they run out upon the epitheca round the rim. They are perforated with multitudes of the same minute pores as the walls. In the base of the fossa they bend round and most of them lose themselves in the columellar tangle. The secondaries in varying numbers are often very pronounced and seem to lift the columellar tangle into ridges. This tangle is a close convex or raised and angular mass of delicate and foaming reticulum, it is very large and unsymmetrical, not seldom running up individual septa.

This coral has already been mentioned and compared with others which closely resemble it in growth-form (p. 76, δ). Formerly the name "*Goniopora Stokesi*" would have been given to all *Goniporæ* showing the same method of growth, but we cannot regard them as a genetic group except by pretending to knowledge which we do not possess. Free stocks on a flattened circular epitheca have evidently been common in this genus, but the known forms show a great diversity of calicle formation. It is probable that they can arise at any time if the parent polyps alight upon a soft and yielding substratum. Some of the differences in calicles can be seen by comparing Pl. VII. fig. 6 with Pl. VIII. fig. 4, and other points can be gathered from the text.

There are 11 specimens gathered from various depths and from several of the principal islands of the Maldives. Together they probably form a well-marked genetic group. Four of these have been presented to the British Museum by Mr. J. S. Gardiner.

a–d. Zool. Dept. 1902. 9. 9–13.

60. **Goniopora Mauritius** (1)**1.** (Pl. VII. figs. 7 and 8; Pl. XIII. fig. 10.)

[Mauritius, coll. de Robillard; British Museum.]

Description.—Corallum is thin and explanate, but the surface rises into blunt club-shaped knobs and columns which fuse together irregularly, and occasionally fork. These columns may rise 8 cm. high, and are from 1–2 cm. thick at the base, but swell unevenly as they rise, though they are not regularly moniliform. The explanate base may grow out horizontally, largely free, resting on the tips of the previous growths, or creep vertically downwards or upwards following the irregularities of the substratum; 1·5 mm. thick at the edge, 6–7 mm. thick in the older parts.

Calicles over the general surface (fig. 8) small, 2 mm., polygonal, open, uniformly shallow ca. 1 mm., with low thick walls consisting of a frosted zigzag thread. The wall is thickened on each side by short closely packed frosted septa, and frequently appears as if striated across the top. The union of these septa by additional synapticulæ frequently makes the wall a close reticulum. The septa are thick and granulated and finely frosted, and show the typical formula with the usual two rows of pali, as large frosted granules rising at the points of fusion. Seen sideways the six large pali rise like clubs not quite as high as the wall. Small granules sometimes rise from the ends of the directives. The columellar tangle is inconspicuous and somewhat obscured by the ring of pali. The interseptal loculi are inconspicuous.

The texture is altered on the tips of the knobs (fig. 7), being there a thin filamentous reticulum with a corresponding diminution in thickness of the intracalicular skeleton and increased size of the interseptal loculi.

There is only one large very irregular specimen, 25 to 30 cm. high by 30 cm. across (see Pl. XIII. fig. 10), growing over several generations of previous growths. It is covered with columns and it is a question as to how far these were originally started by irregularities of the substratum, or are a normal growth. If the latter, they are quite peculiar within this genus. In *Montipora*, in which there is a special development of the cœnenchyma (see Vol. III.) it is common to find explanate stocks from the surface of which vertical columns arise. Contrast this with the tuft formation found in *Goniopora*, also derived from explanate stocks, but by the turning up and curling of the edges, see *G. Great Barrier Reef 12*.

The specimen is entangled with a great mass of calcareous alga and perhaps thereby distorted. Here we have another instance of an explanate *Goniopora* with the regular calicles typical of that growth-form, cf. Introduction, p. 25, and figs. 8, Pl. VII. and 1, Pl. II.

a. Zool. Dept. 83. 7. 27. 14.
b. (A small fragment.)

61. Goniopora Seychelles (1).

[Seychelles; Paris Museum.]

Goniopora Savignyi, Milne-Edwards (*partim*), Hist. Nat. Coralliaires, iii. (1860) p. 191.

Description.—Corallum forms large expanding but compact clusters of round-topped smooth-sided columns, with deep chasms between, and of all sizes, some small, some very thick, reaching mostly to the same general level. The living layer is only 3–4 cm. deep in the central columns, but 16–17 deep on the outer sides of the outermost columns.

The calicles are from 2–3 mm., and are more open and lamellate on the top, shallower and with irregular pali at the sides.

This imperfect description is taken from a sketch and a few pencil notes made in Paris. There were two specimens; the smaller was apparently only a large detached

column or lobe. It was probably the columnar growth which suggested the grouping of this coral with the Red Sea form figured by Savigny in his Descript. de l'Égypte, pl. v. fig. 2. It appeared to me to be quite a different coral, and also different from the other form which Dr. Klunzinger called *G. Savignyi*, and which, like the type, was from the Red Sea, see *G. Red Sea 3*.

The rounded tops and flat sides, with lamellate texture of the tops of the columns, leads one to believe that this must be another instance of the expanding-sheaf formation referred to in the Introduction, p. 26. It is worth noting that it is a very common growth-form of the Red Sea *Gonioporæ*, see Table III. D, p. 171.

Group V.—INDIA AND PERSIA.

Containing descriptions or records of Fossil Gonioporæ from Sind (1–7); *? "Indus River"* (1); *Persia* (1–4).

62. Goniopora Sind (7)1.

[Jakhmari, Laki Range, south-west of Amri (Cretaceous or Lower Eocene, in beds with *Cardita Beaumonti*), coll. Geol. Survey, India; Calcutta and British Museums.]

Litharæa epithecata, Duncan, Sind Fossil Corals, *Mem. Geol. Surv. India* (1880) p. 23, pl. ii. figs. 1–9.

Description.—Corallum thin, flat, disc-shaped, slightly convex with sharp edges, free upon a well-developed concentrically wrinkled epitheca; under surface may be slightly concave.

Calicles rather irregular, usually hexagonal, large up to 6 mm., smaller round the rim. Walls thin, with sharp ridges, irregularly reticulate in sections and tending to rise into points at the angles. Septa long, thin, wavy and conspicuous, in the typical formula, much perforated, with enlargements and lateral echinulations, incised, and bluntly coronulate or moniliform on the free edges, thicker near the wall. The columellar tangle is very slight and inconspicuous at the surface.

This primitive method of growth is now known to have persisted in other *Gonioporæ*, see Table III. As explained in the Introduction, all the other growth-forms of the genus can be deduced from it.*

The variety described by Duncan as *var. hemisphærica*, (l.c. fig. 10) from "Barki nala," is either an older growth-phase or the same coral with the disc more concave below and convex above, for it is to be noted that the calicles are of the same type, and shallow. True hemispherical forms would only occur if the calicles composing the colony were tall with deep fossæ.

It was Duncan's excellent figures of this coral which first led me to the discovery of the septal formula characteristic of the genus.

There is one rather poor specimen in the British Museum, showing no details of the structure so beautifully illustrated by Duncan.

* Duncan thought that the basal epitheca was a point of special importance, and Gregory (Geol. Mag. (1898) p. 250) named certain free Egyptian forms "*epithecata*" without hesitation. See p. 106.

There seems to be considerable uncertainty as to the age of the olive shales in which the Jakhmari specimens occur. Duncan regarded them as Cretaceous, but see Medlicott and Blanford's 'Manual of the Geology of India,' 2nd edition (R. D. Oldham) 1893, p. 287. No argument in favour of the earlier beds can be based upon the fact that the growth-form of the specimens is primitive, for other fossil *Gonioporæ* with the same growth-form are known to be Eocene.

Geol. Dept. R. 13, presented by the Geol. Survey India.

63. Goniopora Sind (7)2.

[South-west of Lynyan, Ranikot Group (Lower Eocene), coll. Geol. Survey, India.]

Litharæa grandis, Duncan, Sind Fossil Corals, *Mem. Geol. Surv. India* (1880) p. 57, pl. xi. figs. 11, 12, 13.

Description.—The corallum is of the primitive shape, only slightly convex above, 25 mm. high and 9 cm. diameter, but below flat round the edges and concave in the centre. [The specimen was elliptical in outline and the epitheca had disappeared.]

The calicles are very large, 10 mm., some even 12·5 mm. in diameter, polygonal and shallow. The walls are stout, reticular, of irregular outline, sometimes protuberant. The septa in three regular and distinct cycles in the typical formula, each septum stout, plain (i.e. non echinulate), often wavy and not very perforate. Both primaries and secondaries meet the small columellar tangle. The interseptal loculi are large and open.

Imperfect tabulæ are formed.

This *Goniopora* stands alone in the large size of its calicles, some 4 mm. larger than the calicles of any other known form, and without any increase in the number of septa.

Duncan added to the description that this "species" is closely allied to *G. Sind 1* (his "*epithecata*"), but differs only in size of calicles and "absence of epitheca." The latter distinction must have been purely accidental. Other distinctions also can be seen in the characters of the septa and walls.

There is no specimen of this or the three following *Gonioporæ* in the National Collection.

64. Goniopora Sind (7)3.

[Jhirk, Ranikot Group (Lower Eocene), coll. Geol. Survey, India.]

Porites superposita, Duncan, Sind Fossil Corals, *Mem. Geol. Surv. India* (1880) p. 57, pl. xiv. figs. 5 and 6.

Description.—Corallum small, elliptical, convex; fresh growths do not quite cover those which preceded them, so that the stock is an irregular pile of convex plates.

The calicles are 2 mm. across, polygonal, often circular, walls frequently reticular. Septa (24) closely crowded, not much thicker near the wall than near the centre, in three distinct cycles, sometimes fusing but often free, and thus not always showing the typical formula. The columellar tangle large, rises to the surface as granules. The perforations of the septa are said to be small.

The figure and description given of this coral are not quite as lucid as one could desire. The columellar tangle is shown only as two or three granules. Are these appearing above a matrix? If so, the septa may well fuse to form the typical formula below the surface shown. In accepting it we rely upon Duncan's diagnosis of the specimen as a true Poritid: if this is so, the septa show it to be a Goniopore.

Duncan's figure suggests that the coral may be another of those retaining the primitive form of growth, only here, as in *G. Maldives 4*, the successive growths are piled up one on the top of the other.

On the name "*superposita*" see the remarks on the name "*Stokesi*," p. 77.

65. Goniopora Sind (7)4.

[Maliri, South of Chotra, top of the Khirthar beds or base of the Nari series (Upper Eocene), Mal Mahori, same horizon; coll. Geol. Survey, India.]

Porites indica, Duncan, Sind Fossil Corals, *Mem. Geol. Surv. India* (1880) p. 67, pl. v. figs. 12 and 13.

Description.—The corallum is massive, with broad irregularly gibbous surface.

The calicles, 2–2·5 mm. across, "are shallow, open but slightly separate, hexagonal or pentagonal or irregular in outline." The walls are mostly reticular, but thin, here and there simple. The 24 septa are long and thin, and not crowded; they show traces of the typical formula.* Their free edges are nodulated (perhaps the result of post-mortem corrosion). A rather wide central columellar tangle, with paliform nodules or rods on its upper surface.

This coral is obviously a *Goniopora*.

66. Goniopora Sind (7)5.

[Near Raduk, 10 miles south-east of Jhangára, Nari series (Upper Eocene), coll. Geol. Survey, India.]

Litharæa nodulosa, Duncan, Sind Fossil Corals, *Mem. Geol. Surv. India* (1880) p. 80, pl. xix. figs. 4 and 5.

Description.—Corallum consists of "short stunted branches," about 5 cm. high.

Calicles from 2·5–5 mm. in diameter, shallow, irregularly quadrangular. Walls thick, and, judging from the figures, composed of reticulum, the elements of which are much thinner than are the peripheral ends of the septa. Septa from 20–30, those of the different cycles very distinct, the longer ones fusing irregularly with a small columellar tangle, but not very much with one another. The septa are wedge-shaped, the free edges being sharp, but their peripheral ends, where they are inserted in the reticular wall, thick and rounded.

As shown in Duncan's figure, this coral is a true Goniopore, so far as one can judge from its surface aspect. The enormous thickness of the septa where they mount the walls, which suggests an Astræid (cf. Duncan's figs. 8, 9 on the same plate), may have been due to post-mortem alteration (see Introduction). The original specimen would probably show whether the septal formula was that typical of this genus. The figure shows no trace of it.

* Not shown in the figure, but implied in the text: "The tertiaries fuse with the secondaries."

67. Goniopora Sind $_{(7)}$6.

[A pebble probably from near Kurrachee, Sind (Eocene), British Museum.]

Description.—The corallum massive.

The calicles small up to 2 mm., polygonal, with distinct walls which may have been sharp and zigzag at the growing surface, but in transverse section are coarse and irregularly thickened, and perforated. The intracalicular skeleton seen in the sections is peripherally a confused reticulum, and might be taken for that of *Porites*; for where the radial symmetry is best shown 12 short rays arranged round a variously developed, usually slight columellar tangle form the most conspicuous feature, but peripherally these septa branch and run together to form a network with rounded meshes. It would be easy to mistake this network in many of the calicles for a thick reticular wall, in which case the coral would be a *Porites* with 12 septa. In others, however, the branching septa look like the ordinary fusing of the tertiaries with the secondaries in *Goniopora*. Without knowing what the walls were like at the original surface, no certain conclusion can be arrived at. I feel justified, however, in assuming that the zigzag lines still persisting and seen in the section formed the true wall at the surface,* and that the skeleton contained within them was at the surface clearly septal. The confused reticulum seen in the section is perhaps due to development of synapticulæ and thickening of the elements such as is common in the basal part of calicles.

My view, viz. that the coral was a *Goniopora* and not a *Porites*, is further confirmed by the presence of the columellar tangle almost unknown in *Porites*, and by the absence of all traces of the septal formula of *Porites*. Cf. the origin of *Porites* from *Goniopora* in the Introduction, p. 21.

In contrast with the general thickening of the walls and septal elements, the columellar tangle remained a delicate open sponge-work.

There is one pebble, which is of a light greyish or brownish pink colour, and a microscopic section.

a. Geol. Dept. $\frac{\text{R.24}}{\text{B}}$ transferred from India Museum, London, 1880.

68. Goniopora Sind $_{(7)}$7.

[Pebbles probably from near Kurrachee (Eocene), British Museum.]

Description.—Corallum massive.

Calicles, seen only in section, about 2 mm. across, and separated by reticular walls 1 mm. thick. The walls are a close reticulum of stout threads of nearly uniform thickness; they show no traces of any median strand which at the surface could have formed a sharp ridge zigzag or straight, such as can be seen in the last specimen. Hence the walls at the surface

* Cf. the structure of the wall in the next form, *G. Sind 7*.

were purely reticular and probably round-topped. The intracalicular skeleton has been replaced by calcite in both specimens, and only traces of the septal apparatus can be seen. The radial symmetry seems to have been obscured and to have been replaced by a reticulum continuing that of the walls, but showing here and there round the margins traces of the primitive radial arrangement. In these cases there seemed to have been about 24 septa, the tertiaries being only faintly developed.

There are two dark purplish-brown specimens which seem to be of the same kind.

a, *b*. Geol. Dept. $\frac{\text{R . 24}}{\text{A \& C}}$, transferred from India Museum, London, 1880.

69. Goniopora India *a*.*

[Jhirk ? † Indus River, Sind (Eocene), coll. Falconer; British Museum.]

Description.—Corallum massive, with convex, slightly wavy surface, edges creeping over former growths.

Calicles 4–5 mm., irregularly polygonal, as shallow concavities with sharp irregular ridge-like walls rising to different heights. The 24 septa conspicuous, but too indistinct to make out in any detail. The columellar tangle appears as if it had been large and sometimes slightly convex.

There is one specimen, which from the surface markings clearly belongs to this genus, but internally the specimen is altered, and become crystalline.

a. Geol. Dept. R. 4809.

70. Goniopora Persia (4)1.

[Islands of Lake Urmi (Miocene), coll. Dr. Abich.]

Porites leiophylla Abich (? Reuss), *Mem. Ac. Imp. Sci. St. Petersburg*, ser. vi. vol. ix. 1 (1859) p. 101 (41).

Dr. Abich has described, as *Porites*, knobbed and shapeless masses fairly common on the islands of Lake Urmi, in the limestone forming the floor of the great cave of the Castle of Maku, and perhaps also recognisable among other fossils from Malishkent.

For a description Dr. Abich repeats almost word for word Reuss' description of his *Porites leiophylla* (see Haidinger's Naturwissentsch. Abhandl., ii. (1848) p. 28). This is not a *Porites* but a *Goniopora*, and is re-described from Reuss' text and figures on p. 123 of this Catalogue under the heading *Goniopora Vienna Basin 2*.

The specific identity of two corals from localities so far apart is perhaps possible, but even if the structural details of the two were as similar as Dr. Abich thinks, I should still be inclined to doubt their being closely allied.

* See prefatory note to Group XIV. p. 156.

† An old label bears the legend "Jink (Indus R.)." I have not succeeded in finding out where Jink is, unless it is Jhirk, or Jhirruck, on the Indus.

71. Goniopora Persia (4)2.

[Bajazid, Araxes Valley ("Supra-nummulitic Limestone" = Miocene), coll. Dr. Abich.]

Litharæa ramosa, Abich (? *non* Milne-Edwards and Haime), Mem. Ac. Imp. Sci. St. Petersburg, ser. vi. vol. ix. i. (1859) p. 102 (42) Taf. ix. figs. 12, *a*, *b*, *c*, *d*, *e*.

Description.—Corallum forms irregular cylindrical stems, 1–1·5 cm. thick, growing up side by side, crowded, and often fusing, owing to lobate lateral outgrowths. The surface is humpy, and often covered with pellicular epitheca.

The calicles (under the epitheca, and that is laterally) are rounded, shallow, and about 1·5 mm. in diameter. The radial symmetry can only be recognised in the arrangement of the granules. Walls thick, with few perforations. If we accept Dr. Abich's interpretation of the section (*l. c.* fig. 12), 16 complete septa early form a nearly solid columellar tangle, the septa and the coils of the tangle being very thick, so that the interseptal loculi and the meshes of the columella are much reduced. But it is very doubtful whether these thick white septa are not really filling-in matter, and the dark lines the true skeleton, as I discovered to be the case in *G. Persia 4*.

The "*Litharæa ramosa*" of Milne-Edwards occurs at Dax in France, and, as Dr. Abich himself points out, has calicles 2–3 mm. in diameter. Both this and the last four afford instances of the way names are used, even by naturalists of eminence, mainly from a natural reluctance to "establish new species" without a special study of all the related forms.

A vertical section figured by Dr. Abich shows the trabeculæ bending outwards from the axis of the rapidly rising stock. A very similar section is seen in one of the specimens of *G. Persia 4*.

The cross section of this latter coral, further, has a very similar appearance to Dr. Abich's fig. 12 *d*, and almost convinces me that he has misinterpreted the fossil, for in *G. Persia 4* the thin dark lines are certainly the coral.

72. Goniopora Persia (4)3. (Pl. XIV. fig. 5.)

[Guverchin Kala,* on the N.W. shore of Lake Urmi (Miocene), coll. Loftus; Brit. Mus.]

Description.—Corallum massive, nodular. The living layer apparently broken up into detached portions, which crept over previous growths, with distinct raised edges, each colony making a mound, hence the nodulation of the mass. On the other hand, the sections show that the growth was continuous; the nodulation and division of the living layer may have been

* For a description of the locality and a section of the rock "Guverchin Kala," see Loftus, Quarterly Journal Geol. Soc., lxi. (1855) p. 305. There is no indication as to which of the strata described these and the following fossils were found in, Nos. 2 or 6. A number of minute "flesh-coloured" particles in the matrix of *G. Persia 4* suggest the more recent of the two

due to the rolling of the specimen during life, the uppermost point acquiring a cap of fresh growth.

The calicles vary from 1·5 to 1·75 mm., probably not very deep, with very thin ridged walls, often showing an irregular zigzag. The septa also very thin and perforated. The typical formula with the six pali, and the directives can be made out. Columella composed of little more than the pali and the central tubercle, and the few threads which connect them at intervals.

This diagnosis has been arrived at only with difficulty. The exposed surfaces, which appear to be well preserved, are quite misleading. They show the walls as thick, round-topped ridges, with the elements of the skeletal reticulum also thick. They had, however, clearly suffered from corrosion before fossilisation (see above, p. 22). The sections, again, near the surface have been confused by infiltration. The true character of the original skeleton is, however, fortunately, discoverable on a section passing some 4–5 mm. below the surface. The figure shows indications of the fusing septa (which by study of many calicles can be seen to have been typical), the pali, and the central tubercle. These characters are enough to establish the right of the coral to a place in this genus. More details than those shown can be made out by comparing calicle with calicle, and the zigzag thread of the wall can also be established; although it is not well shown in the figure, where the calicles are in contact.

There is, however, another specimen which I think is of the same kind, a small nodule broken off from a larger stock. This has exposed calicles showing the character of the skeleton as given in the diagnosis, except that the skeletal elements have been thickened. Taking this fact into account, we can make out the zigzag wall forming a low sharp ridge, the perforated septa, somewhat confused owing to the post-mortem thickening of the skeletal elements, and the six pali rather swollen.

a, *b*. Geol. Dept. R. 4810.
(One sliced fragment belonging to *a*, with typical calicles marked.)

73. Goniopora Persia (4)4.

[Guverchin Kala, N.W. of Lake Urmi (Miocene), coll. Loftus; British Museum.]

Description.—Corallum appears to have been an erect, rounded or oval nodule, laterally compressed, some 4 cm. high, 4 cm. broad, and about 2·5 cm. thick. The vertical section shows the calicles radiating from the point of attachment.

The calicles were about 2·5 mm. across. The walls were thin, zigzag, very perforated and incomplete. The septa were also very thin and perforated, and arranged in the typical formula, with the full number of pali and the directive septa. Columellar tangle very slight, and consisting chiefly of the pali and a central tubercle.

I was at first inclined to regard the white pattern of the section as representing the coral skeleton, as Dr. Abich may have done (see above *G. Persia 2*), but my experiences with the fossils last described (*G. Persia 3*) have led me to see that, in this case at least, the thin dark

lines are the skeleton, and the thick greyish-white threads are filling-in matter. It will be seen from the diagnosis that as regards the calicular skeleton this coral agrees with the last, except in the size of the calicles. The growth-form is also different.

In the remains of the matrix of this fossil are flesh-coloured fragments, the presence of which leads me to believe that this coral came from stratum No. 2 of the Loftus series composing the rock Guverchin Kala (see note to p. 97).

a. (with a sliced fragment). Geol. Dept. R. 4811.

Group VI.—RED SEA AND EGYPT.

Containing descriptions or records of Gonioporæ from the Red Sea (1–6); *Egypt* (1–3) *fossil.*

Red Sea Forms.

The first corals which should here claim our attention are two figured by Savigny in the Atlas to his 'Description de l'Égypte,' pl. iv. fig. 6 and pl. v. fig. 2. Both have from time to time been claimed as representatives of this genus. The former was called *Porites clavasia* and the latter *Astræa sp.* by Audouin who wrote the text.

The former has given rise to much discussion, and has been a great perplexity for the last four years to the present writer. Milne-Edwards regarded it as the same as *Alveopora dædalea* of Forskål. Dr. Brüggemann first described it as an *Alveopora* ("*fenestrata*" Lamarck) and then as a *Rhodaræa* ("*R. lagrœnii*," and the same as *G. Singapore 1*). Mr. Saville-Kent would identify it with an Australian *Alveopora*, while Dr. Klunzinger regarded it as more probably a *Goniopora*. The difficulty lies in the walls having been drawn double, a condition never seen in *Alveopora* except where the skeletal elements have abnormally proliferated. In growth-form, in the conspicuous pellicular epitheca, the shape of the perforations of the wall, and in its spiny septa the coral is certainly an *Alveopora*. The double wall is probably a mistake on the part of the artist.

I am confirmed in this suggestion of inaccuracy by noting the great discrepancy between the two figures given of the second of these corals, which was first recognised by Dana as a true *Goniopora*, and has since been called "*G. Savignyi*." The calicles in fig. 2 show a few conspicuous septa radiating like a star from a centre with large interseptal loculi. In the enlarged figure (2_2) there is no trace of any such arrangement, but a compact mass of irregular, wavy, nodulated septa showing no central columella and all nearly uniform. Such septa could never have given the appearance shown in fig. 2. Either one or the other is wrong. My suggestion, based upon the growth-form of the coral with its straight sides, rounded top, and conspicuous septa, is that it is an old stock of one of the three forms now to be described. It is true that the friable texture of the top is not shown. But, when once a drawing is shown to be inaccurate, we are left to select according to our judgment what we have reason to believe to be correct, and to neglect the rest.

74. **Goniopora Red Sea** $_{(6)}$**1.** (Pl. VIII. figs. 1, 2; Pl. XIII. fig. 12.)

[Koseir, coll. Klunzinger; British Museum.]

Astræa planulata, Ehrenberg, Korallenthiere des Rothen Meeres (1834), p. 95 (*fide* Klunzinger).
Goniopora lobata, Milne-Edwards and Haime, Nat. Hist. Coralliaires, iii. (1860) p. 191.
Goniopora planulata, Klunzinger, Korallenthiere des Rothen Meeres, ii. (1879) p. 45, Taf. viii. fig. 23, Taf. v. fig. 24.

Description.—Corallum forms thick expanding columns with rounded tops, which may divide into lobes, and with smooth flattened sides. The living layer descends 3–5 cm. Epitheca in narrow strips.

Calicles from 3–5 mm., opening on the top in a vertical stroma of bent lamellæ (fig. 1). The wall is constructed irregularly by synapticulæ. The septa are long, wavy, conspicuous, perforated, with ragged edges. From 2–8 septa in most of the calicles rather more conspicuously developed than the rest. At the sides (fig. 2) the walls are either simple or very simply reticular, in which case the septa show as points upon the tops of the walls. The three cycles of septa are prominent even round the margin of the walls and here and there the typical formula can be made out; the primaries and secondaries are hardly distinguishable, and the tertiaries remain rudimentary. The columellar tangle is inconspicuous, rises slightly in the fossa, and in the lateral calicles sends up a confused group of twisted paliform flakes.

The interseptal loculi are well marked and open. The transverse sections show the calicles very clearly as radial arrangements of wavy lamellate septa separated by a reticular wall.

The description is that of the duplicate specimen obtained by the Museum from Dr. Klunzinger. It has, to all appearance, the same essential structure as that obtained by the Paris Museum, numbered Z. 174. *a*. The one figured by Dr. Klunzinger in his Taf. viii. fig. 23 shows a very divergent cluster of columns starting from the summit of an original (dead) column.

The coral is a typical example of the expanding sheaf formation, but it is interesting to note that the lateral calicles are not very regular; the walls are either simple or form a sort of angular reticulum irregularly striated by the septa.

Dr. Klunzinger mentions colonies 20 cm. high, 4–6 cm. thick at the base, and 4–15 cm. across the summit; the specimen in the possession of the National Museum is 16 cm. high, 9 cm. across the base, and 16 cm. across the summit. The living polyps are described as cylindrical, 5 mm. thick, 8 mm. high, with 24 tentacles arranged in "2–3 rows,"* blunt and shorter than the radius of the oral disc. The body is ashy grey changing to reddish grey. The oral disc is a beautiful violet, with white and pale yellow tentacles, with dark points at their tips.

Ehrenberg's coral *Astræa planulata*, with which Dr. Klunzinger identifies his, had brown

* It is probable that this appearance was due to the tentacles being contracted and tightly packed; the author's description of their size and shape helps to confirm this suggestion. Cf. Introduction, p. 17.

polyps with green tentacles. I have followed Dr. Klunzinger in including *G. lobata* M.-E. & H. in the synonymy. I find the resemblance recorded in my Paris notes

For other Goniopores showing this same method of growth, an expanding column consisting of a thickening sheaf of lamellæ, see Table III. p. 171.

As stated above, I believe that the coral figured by Savigny in his Atlas to the Description of Egypt, pl. v. fig. 2, is only an old growth of either this coral or one of the two next. Beautiful as the drawing is, it is obviously inaccurate, for the figures of the enlarged calicles are not at all like those shown on the complete stock. There you see only a few conspicuous septa just as in this coral, and the calicles large with rather thick walls. On the coral which Dr. Klunzinger would identify with that figured by Savigny, see *G. Red Sea 3.*

a. Zool. Dept. 86. 10. 5. 51.

75. Goniopora Red Sea (6)2.

["Red Sea"; Leyden Museum.]

A *Goniopora* very similar to the foregoing is in the Leyden Museum and was kindly lent by Dr. Horst for examination. It is also from the Red Sea. It shows the same columnar growth with triangular cross section, the same lamellate wavy septa with inconspicuous synapticular walls, and the same friability at the top. But, on the other hand, the calicles are very much smaller (the largest only 3 mm.) and deeper, and the texture of the cross section is much closer.

This last difference may be solely due to the smaller size of the calicles and hence of the interseptal loculi.

One other difference made the specimen of special interest: the septal teeth are specially long, like bent spines, not unlike those that represent the septa of *Alveopora*, while further in the depth of the fossa these spines unite to form an open reticular tangle as is also typical of that genus. On this account I was for long in doubt whether the specimen might not supply us with a clue to the mysterious coral figured in Savigny's Atlas, 'Descr. de l'Égypte,' Zoophytes, pl. 4, fig. 6, which was called *Porites clavaria* Audouin.

I am now, however, satisfied, for reasons given in the remarks p. 99, that Savigny's coral is a true *Alveopora*.

76. Goniopora Red Sea (6)3.

[? Koseir, deep water on the steep face of the reef; coll. Klunzinger.]

Goniopora savignyi, Klunzinger (? *non* Dana), Korallenthiere des Rothen Meeres, ii. (1879) p. 45, pl. viii. 24 and v. 23 (juv.)

Description.—Corallum produces a cluster of short, thick, angular columns with round tops, all swelling as they rise, and all rising from a common stem. The columns are of all sizes and have flattened sides. Their lobate tops fit fairly close together, 1·5–2 cm. apart. The living layer is from 2·5–3 cm. deep.*

The calicles variable in size from 2–4 mm., but mostly small, polygonal, often subcircular, about as deep as they are broad, except the lateral calicles which are shallow. Walls thin, with sharp spiny edges, the septa not showing at the edge except on the thicker and more granulated

* Reckoned from Dr. Klunzinger's photograph, which is given as one-fifth the natural size.

walls of the shallow lateral calicles. Septa 18–24 in number, very narrow, frequently fusing near the centre, but without columella or pali. Traces of pali can be seen only in the lateral calicles. The texture is loose and open and the stock light. The calicles can be traced deep in the skeleton.

Dr. Klunzinger found one large specimen of this coral 55 cm. across and 40 cm. high, and when dried, of a brown colour. The growth-form, rounded tops, flat sides, loose open texture, and the persistence of the calicles through the sections are all characters suggestive of the expanding sheaf method of growth. In the illustration, given by Dr. Klunzinger, of a young stock we can see the tendency to early mounting upwards, and the lamellate septa, both essential for the production of this growth-form. The author may be right in claiming this to be the same kind of coral as that represented in Savigny's figure, but Savigny's figures hardly fit into the above description. The calicles are there shown large and shallow, and with a central star arrangement of the septal skeleton, whereas in Dr. Klunzinger's specimen they were mostly small. The interesting point is the discovery that so many of the Goniopores of the Red Sea show the expanding sheaf method of growth. Is this due to close relationship or to the influence of the environment?

The next form appears at first sight to be a very different coral, hardly belonging to this genus, but it is capable of being arranged in serial order with this and the foregoing, thus finding a definite place in the genus which it would be otherwise difficult to assign.

77. Goniopora Red Sea $_{(6)}4$. (Pl. VII. fig. 9; Pl. XIII. fig. 11.)

[Red Sea; British Museum.]

Probably nearly allied to "*Rhodarœa gracilis*," Milne-Edwards and Haime, Les Coralliaires, iii. (1860) p. 184.

Description.—Corallum rises by successive caps covering previous convex growths, and always increasing in size. Whether owing to the accidental attachment of foreign organisms or as a normal growth-process the successive layers gradually expanded laterally with free edges so as to form a mushroom-shaped stock (Pl. XIII. fig. 11).

The calicles (fig. 9) are minute, 1·5 mm., flush with the surface, densely crowded as breaks in an elegant open friable reticulum composed of smooth filaments of uniform thickness bent and twisted at all angles and ending at the surface in knobs or flakes. The walls simple and irregularly angular, membranous, but with such large oval fenestrations that they hardly interfere with the transparency of the reticulum when looked at slantingly. Some 6–10 of the septa are rows of long filaments bent upwards and sideways, the rest remain rudimentary round the thin jagged margin of the wall; no definite arrangement can be made out, except that they frequently fuse together and the larger meet with an open axial reticulum hardly dense enough to be differentiated into a columellar tangle, excepting in the lateral calicles. Pali rise to the level of the wall as filaments bent up from the filamentous septa; they carry up the axial reticulum.

At the sides the walls thicken and are reticular, the reticulum being formed partly of flakes bent and twisted at various angles with the surface. The radial symmetry becomes more pronounced. The interseptal loculi are throughout large and open.

The vertical section shows a very compact sheaf of perforate laminæ expanding rapidly, hence the mushroom shape of the stock.

This single specimen appears in Brüggemann's MS. Catalogue as *Rhodarœa? gracilis* M.-E. & H.; to which indeed it is, I think, for reasons given below, very closely allied.

In the character of the skeleton (fig. 9) this is one of the most remarkable representatives of the genus. Indeed at first sight its right to a place may be disputed. I have no doubt myself as to its claims to be placed here. The characters are all those of *Goniopora*: viz. the early convex growth-form, the formation of edges (in this case wide and overhanging) very common in this genus, the porous walls remarkable only in the size of the pores, the fact that there are more than 12 septa, the larger of which fuse to form an axial tangle with pali. This is not all, we can fortunately assign a definite place to it within the genus; it is evidently, as suggested under the last heading, an extreme specialisation of the expanding sheaf formation. The calicles are all formed of a sheaf of membranous walls, the septa being represented by threads; this can be seen in the section. The expansion is so rapid and marked that there are no drooping edges, but the top spreads out like a mushroom. This then is to be regarded as an extreme form along a definite line of growth, which fully accounts for its peculiarities.

In addition to this specimen, there is a beach-worn pebble from some unknown locality, the *Alveopora excelsa* of Brüggemann's MS. Catalogue (Pl. XIV. fig. 1), which has been built out of a sheaf of membranous walls, and shows signs of having once had a thick free edge. Its walls and intracalicular skeleton show somewhat the same structures (Pl. VIII. fig. 8) and the calicles are the same size. The chief difference is in the slightly greater thickness and more laminate character of the skeletal elements. Both these differences can be accounted for by the wearing down of the original surface which would be thinner than the older internal skeleton. This thickening of the internal skeleton is seen in the type specimen which had been split in half during life.

Hitherto no light has been thrown upon this worn pebble. It had no recorded locality and its position in the coral system was a puzzle. We have now discovered that the peculiar method of growth which made its generic affinities so puzzling is common to other *Gonioporæ* of the Red Sea. But, as it is a specialisation of the sheaf type of growth-form which is known elsewhere than in the Red Sea (see Table III. p. 171), there is no reason why a variation on it should not also occur elsewhere; in the meantime, however, this peculiar modification is only known to occur in the Red Sea and we can therefore provisionally refer the pebble to this region. On account of the uncertainty, however, it will be mentioned again among the forms from unknown localities, see p. 157, *Goniopora xb*.

There are two other Corals in the collection showing much the same specialisation, one from a raised beach in the Red Sea, see *G. Red Sea* , and one from some unknown locality and described under the heading *Goniopora xc*, p. 159

Further, there is a coral, also from the Red Sea, photographed by Dr. Klunzinger as "*G. Lichen* Dana," and here described under the heading "*G. Red Sea 5*," which appears also to belong to this group.

Lastly, the originals of Milne-Edwards' *Rhodarœa gracilis* in the Paris Museum are also closely allied. I gather this from my notes, for the original corals reminded me of the

mysterious pebble above described. There are two specimens showing remarkable differences, yet of the same general type. The name "*gracilis*" could only then refer to a type of structure; to class all these into a "species" called *gracilis* would be a pure assumption.

a. (A mushroom-shaped growth which has been split in half.)

Zool. Dept. 40. 5. 7. 19.

78. Goniopora Red Sea (6)5.

[? Koseir, in narrow cleft near outer edge of the reef; coll. Klunzinger.]

Goniopora lichen, Klunzinger, Korallenthiere des Rothen Meeres, ii. (1879) p. 46, pl. v. fig. 22.
Non *Goniopora lichen*, M.-E. & H. (= *Porites lichen* et *P. reticulosa*, Dana), Les Coralliaires, iii. (1860) p. 192.

Description.—Corallum forming small, encrusting, slightly convex stocks from 1–4 cm. across, sometimes with free edges supported by epitheca.

Calicles small (1·5–2 mm., rarely 3 mm.), polygonal, very shallow; walls thin with edges roughened by projecting trabeculæ; 12 septa visible, but with traces of a third cycle; the inner edges form a conspicuous crown of pali, upon a reticular columella. The radial arrangement within the calicle often obscured.

This is from the original description of Dr. Klunzinger. The photograph, which is very distinct, shows a calicular structure not very unlike that of *G. Red Sea 4*. The small calicles with thin walls suggest a relationship, especially as both corals occur in the Red Sea. But Dr. Klunzinger's coral is encrusting and only slightly convex, that is, it is of a very different type from the expanding-sheaf form from which we would deduce the coral last described. It is possible that Goniopores of this group may be modified for the peculiar situations in which they grow, and may lose the growth-form which originally gave rise to their peculiar calicle structure. In more favourable situations these might develop into stocks showing the typical growth-form.

The polyps of this coral are said to be very extensile. The tentacles, of which there are more than 12, are conical, rather long, brown in colour, passing into violet with lighter tips. The oral disc is of a beautiful emerald green with numerous black radial stripes.

Dr. Klunzinger's synonymy seems to suggest that Milne-Edwards and Haime described a coral which they called *Goniopora lichen*. They merely gave this name to the two species of *Porites* described by Dana under separate names. Dr. Verrill, who has had Dana's original specimens, did not accept the alteration of the generic name proposed by the French naturalists; see Introduction, p. 12.

79. Goniopora Red Sea (6)6. (Pl. VIII. fig. 3; Pl. XIII. fig. 13.)

[Rasal Mashiyet, Sinaitic Peninsula (Post-Pliocene), raised beach, coll. J. Milne; British Museum.]

Description.—Corallum grew into rapidly expanding masses or ridges, being composed of an expanding sheaf of stout lamellæ as seen in section. The single specimen seems to consist

of a fragment of the top of a ridge, upon which a smaller ridge had started, one side of this new ridge bulged outwards and overhung, the other had a creeping edge.

Calicles small, slightly over 2 mm., depressed, about 0·5 mm. deep, irregularly cup-shaped; walls about 1 mm. thick, very coarse, reticular, and consisting of a few very thick, twisted, vertical flakes or perforated laminæ, running in the direction of growth; in the lateral calicles, their tops are striated by the septa. These latter are also very irregularly perforated laminæ, the pores being large and often in single rows, sometimes vertical, sometimes sloping upwards towards the axis. They are very twisted, with a confused radial arrangement, sometimes meeting to form a central ring or a small, coarse tangle. The septa fuse so irregularly that it is difficult to count them, 12 can generally be seen meeting the columella, but these branch and fuse near the wall in a manner showing very slight traces of the typical formula. In the exposed sections, the most conspicuous feature is the immense number of stout septal laminæ like flakes projecting above the surface of the fracture.

This interesting sub-fossilised *Goniopora* from the shores of the Sinaitic Peninsula appears to be a transition form between the two, *Goniopora Red Sea 1* and *2*, and the group last described under *G. Red Sea 4*. It shows the open skeleton, the sheafs of laminate septa perforated so as to be almost filamentous, and the walls also with large oval holes.

The surface has unfortunately been too worn away for more accurate diagnosis of the calicular skeleton; fig. 3 is practically a section.

a. Geol. Dept. 56375.

80. Goniopora Egypt $_{(3)}$1.

[El-guss-abu-Said, older strata of Libyan steppes (Lower Eocene), coll. Rohlfs.]

Litharæa sp., Pratz, *Palæontographica*, xxx. (1883) part ii. p. 223.

Description.—Corallum cylindrical.

Calicles vary in size from 3–5 mm., moderately deep, irregularly polygonal. Walls lattice-like. Septa very thin, 20–24, about half of which unite into a large reticular columellar tangle.

Only one badly preserved specimen is recorded among the collections included in Professor Zittel's 'Beiträge zur Geol. und Pal. der Libyschen Wüste,' and provisionally described by Pratz. The cylindrical growth suggests that the specimen was part of a branching form. No allusion to its being a fragment is made in the description. The septa are thin and the columellar tangle is large, as is the case in *G. Egypt 3*.

81. Goniopora Egypt (3)2.

[Wadi-Ramlieh in the Arabian Desert, Middle Egypt ("ober-Tertiären Schichten"), coll. Schweinfurth; Berlin Museum.]

Litharæa rudis, J. Felix (? *non* Reuss), *Zeitsch. d. Deutsch. Geol. Gesellschaft*, xxxvi. (1884) p. 446.

Description.—Corallum massive, lobed ("knollig") with surface more or less convex.

The calicles 5–7 mm. across, moderately deep and of irregular polygonal outline. Wall rather high, simple, sharp, and thus the calicles are not separated by much reticular mural tissue. Three well-developed cycles, and sometimes a fourth incomplete cycle. A more or less well developed reticular columellar tangle.

Dr. Felix had three specimens which were badly weathered but admitted of comparison with several specimens of the coral called by Reuss *Litharæa rudis* (see p. 110, *G. Vicenza 6*) which were in the Berlin Museum. One of the special features in Reuss' coral is the extraordinary development of the synapticulæ, which is not mentioned by Dr. Felix.

The same writer mentions the occurrence of *Porites ramosa* Cat., which was a Goniopore, in other localities in Egypt in Lower Tertiary beds.

82. Goniopora Egypt (3)3.

[Dungul Wells, in the desert, N.L. 23° 30′ and a little south of Silsileh on the Nile, about 24° 40′ (Lower Eocene), coll. Geol. Survey Egypt; duplicates in the British Museum.]

Litharæa epithecata, Gregory (*non* Duncan), *Geol. Mag.* (1898), p. 250, pl. viii. 7 and ix. 6.

There seem to have been several specimens grouped under the survey numbers 306 (? number of specimens), 165 (2 specimens), 176 (? specimens), and 183 (? specimens); the first group from Dungul Wells, and the other three from near Silsileh. They all seem to have had the same primitive method of growth on a circular epithecal plate, and on this account Dr. Gregory called them all *L. epithecata*—which was Duncan's name for a Sind fossil with the same primitive form of growth. But as this growth-form can reappear at any time with very different types of calicles, the specific name *epithecata* is merely a snare.

Duplicate specimens of the Egyptian Survey Nos. 165 and 306, and one slide of No. 183 are in the British Museum. From these we gather that the calicles seem to be about 4–5 mm. across (Nos. 306, 165, 183), are deep in specimen No. 183, see *l.c.* pl. viii. fig. 7 (though the specimens are too altered to give any idea of the original depth). The walls are shown thin and membranous in Dr. Gregory's pl. ix. fig. 6 which was taken from part of No. 306, but in the duplicate of that number in the British Museum Collection, which is a cast, the walls appear to have been rather thick.

The septa are thin in all the duplicates and in the last quoted figure.

The columellar tangle is large and reticular in the two duplicate specimens and it is indicated as such in the figure above quoted. The interseptal loculi were large and open.

Dr. Gregory divided the specimens into two groups, one slightly convex and the other hemispherical, corresponding with Duncan's *L. epithecata* and var. *hemispherica*. As above

pointed out, the only real similarity between these and the Sind corals lies in the fact that they both retained the primitive growth-form of the genus (cf. Introduction, p. 23). The calicles of the Sind form had, according to Duncan, hardly any columellar tangle and the septa were long and laterally echinulate.

a, *b*. Geol. Dep. R. 4812; and R. 4813.

Group VII.—ITALY.

Containing descriptions and records of fossil Gonioporæ from the following provinces and districts: Vicenza (1–13); *Verona* (1–2); *Alessandria* (1–3); *Turin* (1–3); *Genoa* (1–5).

83. Goniopora Vicenza (13)1.

[S. Urbano, Vicenza (Middle Eocene [" Calcaria grossolana "]).]

Porites ramosa, Catullo (*non* Reuss, see p. 110), Terr. sediment. sup. Venezie Antozoari, etc. (1856) p. 77, pl. xvii. fig. 6 A, B.

Description.—Corallum forms thick shapeless columns, from the tops and sides of which thin, short (1–2 cm.), shapeless knobs project like branches.

The calicles seem to have been obsolete or only slightly pitted, separated according to the figure by distinct walls, but not raised, nor thin and thread-like. In the original text, they are said to be wanting or very imperfect. The septa are said to be difficult to make out except under a strong lens, and then they are seen to be " very numerous."

The last recorded fact shows that this coral, if a Poritid, was a *Goniopora*. That figured with it by Catullo as *Porites tuberosa* hardly seems to be a Poritid at all.

The name *ramosa* has clearly been a great snare. Nearly all the branching fossil Poritids have been called either *Porites*, or *Litharæa ramosa*. Reuss gave the same name to a *Goniopora* from Crosara, but because it differed from that of Catullo, he concluded that Catullo's figures were bad (see p. 110). Milne-Edwards described a *Litharæa ramosa* from Dax (see p. 128), and Dr. Abich " identified " a branching Poritid from Persia with the *Litharæa ramosa* M.-E. and H. (see p. 97). Dr. Felix mentions *Porites ramosa* Cat. as apparently abundant in the Lower Eocene of Egypt (see p. 106). Unless the corals were far more stable structures in early Tertiary times than they are in modern seas, such identifications answer no useful purpose whatever.

As a further example of this method, D'Achiardi, in his Catalogue of the fossil corals from the nummulitic limestone of the Venetian Alps, 1867, identified Reuss' *P. nummulitica* with this coral. Against this Reuss objected in his description of the specimens from Crosara which he thought were the same as Catullo's *P. ramosa*. I merely call attention in passing to these assertions and contradictions. Affinities are not worked out in this way.

The only Vicentine branching form in the National Collection is from a place called " Fontana della Bove," and was purchased as *P. ramosa* Cat.; for a description of it see p. 114.

84. Goniopora Vicenza (13)2.

[Croce Grande di S. Giov. Ilarione, Valle di Ciupio (Middle Eocene).]

Porites Pellegrinii, D'Achiardi, Corall. Foss. Nummulit. Alp. Venete, Pisa (1867), p. 10.
? Porites pellegrinii, D'Achiardi, Coralli Eocen. Friuli, Atti Soc. Toscana Pisa (1875), vol. i. p. 203.
? Porites pellegrinii, Reuss (see below, p. 111).
Non *Porites pellegrinii*, Duncan, Sind Foss. Corals, *Mem. Geol. Surv. India* (1880) p. 67, pl. v. iii.

Description.—Corallum dendroid, branches thin and irregular, some compressed, some cylindrical.

Calicles shallow, 1–2 mm. across, walls thin, usually 16 septa, rarely 24, almost all free, denticulate.

"This fossil was so well preserved that it might almost have been taken fresh from the sea." Under these circumstances one regrets that it was not well figured. Owing to this omission and to the shortness of the description we have no means of deciding whether the coral which Reuss, in 1874,* described doubtfully as *P. pellegrinii* D'Ach., from the same locality, is or is not the same. It is true that D'Achiardi, in 1875, working on specimens from a different locality (Rosazzo) accepted the identification. But the significance of this is discounted by the fact that he made no observations on the differences between his and Reuss' descriptions. Further, Duncan's *Porites pellegrinii* is a true Porites and does not belong to this genus.

A similar coral is said to occur at Ronça (see *G. Verona 1*).

85. Goniopora Vicenza (13)3.

[Monte Grumi near Castel Gomberto (Oligocene).]

Porites minuta, Reuss, Denkschr. K. Ak. Wiss. Wien, xxviii. (1868) p. 164, pl. xv. fig. 8.

Description.—Corallum apparently a hemispherical mound, built up of concentric layers.

Calicles crowded, polygonal, 1·5–2 mm. across and very shallow. Walls low, sharp ridges. Septa 14–18, thin, irregular, much perforated, and with upper edges granulated, with only the remains of the typical formula. The septa often fuse together quite close to the walls, and are also joined by thin irregular synapticulæ. The six typical pali form a ring, in the centre of which rises a small inconspicuous collumellar tubercle.

A vertical section shows an irregular fine reticulum.

The author adds that this is distinguished from his *P. nummulitica* (see next heading), with which it occurs, by having smaller calicles and thinner septa.

* Denkschr. K. Ak. Wiss., xxxiii. p. 17, pl. xl. figs. 9 and 10.

The specimen is chiefly interesting because at first sight it has the habit of a true *Porites*. It is one of those Goniopores which are either really approaching *Porites*, or merely acquiring a superficial resemblance (see Introduction, p. 21).

86. Goniopora Vicenza (13)4.

[Crosara, near Marostico (Oligocene).]

Porites nummulitica, Reuss, Denksch. K. Ak. Wiss. Wien, xxix. (1869) p. 250.
? Porites nummulitica, Reuss, Denksch. K. Ak. Wiss. Wien, xxiii. (1864) p. 28; and xxviii. (1868) p. 164, etc.

Description.—Corallum forms mounds 9 cm. across, rising often very high from broad bases.

The calicles are said to be 2–3 mm. across, shallow, and irregularly angular; in other points it is said to be exactly like specimens of the same "species" from the Oligocene at Oberburg in Styria and Castel-Gomberto.

As Reuss' work is always excellent, it is safe to call attention to the similarity said by him to exist between specimens from these different localities. Yet I can hardly doubt but that other differences could now be found, besides those admitted in growth-form and in the sizes of the calicles.

87. Goniopora Vicenza (13)5.

[Crosara, near Marostico, Vicenza (Oligocene).]

Porites micrantha, Reuss, Denksch. K. Ak. Wiss. Wien, xxix. (1869) p. 251, pl. xxvi. fig. 4 *a*, *b*.

Description.—The corallum massive with convex but slightly wavy surface.

Calicles 2·5–3 mm. across, polygonal and shallow. The walls are low, thin, but with blunt and irregularly granulated edges.

Septa "22–26," thin, very crowded, and so wavy and irregularly fused together as almost to obscure the radial symmetry. The columellar tangle does not appear at the surface, and the centre is occupied by the typical six pali surrounding a columellar tubercle.

The waviness of the septa seen in this form occurs also in *Goniopora Oberburg 2*, called by Reuss *Litharæa lobata*. It is carried to an extreme in many of the Paris Basin forms, see Plates IX. and X.

Reuss suggested that this might perhaps be allied with the "*Astræa microsideræa*" Catullo,* which D'Achiardi † claimed as *Porites*; but Catullo's figure seems to show a distinct groove along the wall ridges which, though occasionally seen (Pl. II. fig. 3) is not a characteristic of the Poritidæ, but is of many Astræidæ. As D'Achiardi gives a different locality, he was

* Terr. Sediment. sup. Venezie Antozoari, etc. 1856, p. 62, pl. xiii. 5 *a*, *b*.
† Corall. Foss. Nummulit. Alp. Venete (Pisa 1867).

apparently working with specimens which he merely thought might be specifically identical with Catullo's coral!

Martin Duncan specially mentioned the "*Porites micrantha*" of Reuss as allied to his "*P. indica*" from Sind, but on what ground he did not state. We may note that the Sind Goniopore (see p. 94) has no trace whatever of the wavy septa which is the special characteristic of this coral from Vicenza.

88. Goniopora Vicenza (13)6.

[Crosara, near Marostico, Vicenza (Oligocene); several specimens in the Berlin Museum.]

Litharæa rudis, Reuss, Denksch. K. Ak. Wiss. Wien, xxix. (1869) p. 251, pl. xxvii. fig. 2.

Description.—Corallum smoothly or irregularly convex.

Calicles deep and 4·5–6 mm. across, irregularly polygonal. Walls as tall, simple ridges, not specially zigzag, with rough, irregularly granular or bluntly echinulate edges. Septa 24–30, somewhat thick, with granular edges and perforated with numerous rounded holes; six of them are frequently prominent. Synapticulæ, in all stages of formation, often unite the septa. The columella is neither large nor small and rises at the surface into paliform knobs ("papillæ").

The septa in this coral, instead of being twisted into a reticulum, are joined by multitudes of synapticulæ; both methods produce a kind of grating over the mouth of the fossa. See remarks on the Paris Basin specimens p. 146.

The blunt echinulations which project from the edges of the walls are the beginnings of the septa, and the thin wall is hardly continuous enough to be either threadlike, zigzag, or wavy; it seems at the edges to be composed of the broad bases of the septal points.

This specimen is very interesting, because of the high walls. It is common enough in fossil *Gonioporæ* to find the walls raised, but unless one can be certain that the original surface has been preserved, this character cannot be trusted. The only clear case of high walls among the fossil *Gonioporæ* in the National Collection is that of the specimen received as *Litharæa desnoyersi* M.-E. & H. from Hauteville (see p. 143). Cf. also *G. Egypt 2* which had other points of similarity with this coral, e.g. large calicles. On this last feature cf. *G. Sind 2*, called by Duncan "*grandis*," on account of the great size of the calicles, although the septa were not increased in number as they are said to be in Reuss' coral here described.

89. Goniopora Vicenza (13)7.

[Crosara, near Marostico, where it is present in such quantities that many of the layers are almost composed of it (Oligocene).]

Porites ramosa, Reuss, Denksch. K. Ak. Wiss. Wien, xxix. (1869) p. 250, pl. xxvi. figs. 1–3; pl. xxvii. fig. 1.

Description.—Corallum rises in thick, irregular, nearly cylindrical columns which divide at small angles; the double columns thus formed secondarily fuse together. The tops of the

branches are rounded. Forms in which the forkings are more divergent also occur; in these the rounded tops sometimes divide into three (*l.c.*, pl. xxvii. fig. 1). The thickness of the stems varies, being apparently secondarily thickened by downward growths from the living tops.

The calicles are most conspicuous on the youngest tops where they have slightly raised walls. They are here 2–2·7 mm. across and slightly pitted: lower down they are quite flush with the surface. The walls are thin, wavy, and echinulate, and here and there incomplete. The septa are 24 * and show clear traces of the typical arrangement in which the tertiaries bend round to fuse with the secondaries between them. Their upper edges are sharply granulated. Six very small pali surround an inconspicuous central tubercle; they are shown so very much smaller than the septal granules, whereas they should be so much larger (see diagram A, p. 21) as to make a re-examination of the specimens a desideratum.

The *Porites ramosa* of Catullo, from "S. Urbano" near Montecchio Maggiore, may or may not be the same. Catullo's figures may be bad, as Reuss suggests. But considering the difference in locality, and in the character of the septal skeleton, which is clearly indicated in Catullo's figures as rigidly radial, we must keep them apart.

There is a branching form in the National Collection labelled *P. ramosa* Catullo, from "Fontana della Bove." It is also said to be "Oligocene," but both from the surface aspect and from the section, which is obscured by the hollowing out of the skeleton by a parasitic alga, one would say the walls were thick and reticular, and hence not like those of this coral. See description below, *G. Vicenza 12*.

The great beds of branching *Gonioporæ* found fossil at Crosara remind one of the beds of branching *Porites* now living in the West Indies and on the Florida reefs, but, as far as I know, not in any other localities.

90. Goniopora Vicenza (16)8.

[S. Giov. Ilarione (Middle Eocene).]

Porites pellegrinii, Reuss (*partim*), Denksch. K. Ak. Wiss. Wien, xxxiii. (1874) p. 17, pl. xl. figs. 9, 10.

? *Porites pellegrinii*, D'Achiardi, Corall. Foss. Nummulit. Alp. Venete (Pisa 1867).

? *Porites pellegrinii*, D'Achiardi, Atti Soc. Toscana (Pisa 1875), p. 203.

Non "*Porites pellegrinii*," Duncan, Sind. Foss. Corals, *Mem. Geol. Surv. India* (1880) p. 67; pl. v. figs. 14 and 15.

Description.—Corallum forms small, compressed, lobate colonies ("lappig-ästig"). This method of growth is fairly constant.

Calicles not over 2·5–3 mm., irregularly polygonal or rounded-hexagonal, very shallow. Walls very low, but sharp and perforated.

Septa 16–20, nearly uniform, thick near the walls, short, ending freely, and pointed;

* Reuss wrote 10–14, of which 5–8 reach the axis. It is true that they are often confused, but his figure 1 *b* leaves no doubt whatever but that the typical formula (see Introduction, p. 21) underlies the confusion.

their upper edges are covered with sharp denticulations and the sides with pointed granules; seen from above they have a tapering moniliform appearance (see footnote below); perforations small and only in the "middle parts."

The pali show the regular number (6) and form typical of this genus (see p. 21, Introduction) as radially flattened grains, with a slightly flattened columellar tubercle (sometimes broken into 2–3). Below the surface the septa join a rather dense, spongy columellar tangle and sometimes meet and fuse on the way.

· This is one of the cases in which we have to deal with an uncertain locality, see Introduction, p. 35. We assume that the description and figures refer to the specimens from S. Giov. Ilarione, but of course we cannot be sure. The simple facts are that Reuss had *Gonioporæ* from this locality and from Ronça, and that he thought them to belong to the same "species" because of their similarity. In view of the uniform excellence of Reuss' work he was probably correct, but in conformity with the method of presenting the corals adopted in this catalogue, we have to fall back upon the bare facts. We accordingly record a *Goniopora* from S. Giov. Ilarione, and another from Ronça, and we give the description, which with many authors would have been founded on both corals and therefore worthless, under the first named locality.

D'Achiardi had already described a form from S. Giov. Ilarione, and Reuss thought that his might be the same; but, as Reuss points out, there are serious doubts, for although D'Achiardi's specimen was very perfectly preserved he says nothing about the pali, structures which though typical of *Goniopora*, are rarely seen so well preserved as they were in Reuss' specimens: cf. his fig. 9*a*.

The peculiar moniliform* septa shown in Reuss' figure evidently led Martin Duncan to give this same name to a badly preserved fossil coral from Sind. As Duncan's coral has only 12 septa it is here regarded as a true Porites, and will be recorded in Vol. V.

91. Goniopora Vicenza (13) 9.

[S. Giov. Ilarione; Middle Eocene.]

Litharæa sp., Reuss, Denksch., K. Akad. Wiss. Wien, xxxiii. (1874) p. 18.

Description.—Calicles 3–3·5 mm. across, polygonal, "moderately deep." Thin reticular walls ["spärliches Cœnenchym"]. Septa thin and much perforated. Columella poorly developed.

This is all Reuss says of another true *Goniopora* from this locality. It was unfortunately badly preserved. Its presence, however, as a form quite distinct from that named *P. pellegrinii* by Reuss, and in manner of growth differing from that called *P. pellegrinii* by D'Achiardi in 1867, shows that the genus was well represented in this district.

* On the probable post-mortem origin of this character in fossils, see footnote, p. 22.

92. Goniopora Vicenza (13)10.

[Crosara, near Marostico (Oligocene), coll. Michelotti; Geol. Mus. Univ. Rome.]

Rhodaræa dissita, Angelis, *Atti R. Accad. Lincei*, i. (1895) p. 181 (text fig. 10).

Description.—Corallum grew into small irregularly knarled nodules. The lobes or branches are angular and flattened. The bases may be as small as 8 mm. in diameter.

The calicles are of all sizes from 1–2·5 mm. and of varying depths, mostly shallow. The shape of the calicle is variable owing to the irregularities of the surface, but regularly polygonal on smooth parts. The septa (24) are thin and very pronounced, and with denticulate edges.* Quite irregular in their fusions, most of them running singly towards the large open columellar tangle which sent up pali-like points into the fossa. The interseptal loculi are large, open, and pear-shaped, being mostly rounded peripherally. The walls too, when reticular, have large, angular, open meshes.

The single specimen was kindly lent for examination by the Director of the University Geological Museum, Rome.

The ends of the threads of the irregular columellar tangle evidently suggested the generic name *Rhodaræa*, given it by Dr. Angelis (see Introduction, p. 16, on the genus *Rhodaræa*). It is quite unlike any of the other Crosara forms, but on the other hand the surface aspect of the calicles in the specimen is very like that shown in the fig. of Reuss' "*P. pellegrinii*" (S. Giov. Ilarione) from the same district, in which also the denticulations were apparently altered by aqueous action into smooth round knobs. The growth-forms are also somewhat similar, in that they are both irregular, flattened, forking masses.

The chief feature of interest is the fact that though there are the typical number of septa, it is only in the smaller calicles with fewer septa that we find any traces of the typical formula; the secondaries with their adjacent tertiaries forming three-pronged forks against the wall.

93. Goniopora Vicenza (13)11.

[Crosara, near Marostico (Oligocene), coll. Michelotti; Geol. Mus. Univ. Rome.]

"*Litharœa eximia*" (Meneghini in litt.), Angelis, Atti R. Accad. Lincei i. (1895) p. 179, fig. 7 in text.

Description.—Corallum forms small circular discs upon a concentrically wrinkled epitheca. The whole often greatly crumpled and attaining a thickness of 7 mm.

Calicles 2 mm. in diameter, polygonal, depressed, with thick raised walls sometimes ridged and sometimes round-topped. Seen by the naked eye, the slopes are closely striated by the septa. The septa appear very crowded and 24 in number, descending into the calicles as rows

* The denticles have here for the most part suffered post mortem alteration into thick rounded knobs, as may be gathered by comparing them with the skeletal elements in the section which are thin.

of teeth or nodules * towards a large, irregular, and obscure columella. In section (Angelis, *l.c.* fig. 7, the original preparation of which I have been privileged to see) they are thin with large, open interseptal loculi and show very plainly the typical fusion of the tertiaries with the secondaries. There are traces of a union of two septa across the calicle to form a directive keel.

The specimen has the typical skeletal formula somewhat obscured by the waviness of the septa, and their frequent interruption owing to perforations. There are five other representatives of the genus known from Crosara; one of them (viz. that called "*Porites ramosa*" by Reuss) was specially abundant, and all have somewhat the same general characters of the septa. The "*G. rudis*" Reuss has much larger calicles, 4·5–6 mm., and they are deep. The "*G. ramosa*" Reuss (not of Catullo) has calicles of about the same size, but the method of growth is strikingly different, while the "*G. micrantha*" Reuss, with calicles 2·5–3 mm. across, has from 22–26 and even 30 septa, very wavy and crowded.

94 Goniopora Vicenza $_{(13)}$12. (Pl. XIV. fig. 6.)

["Fontana della Bove," Vicenza (Oligocene); British Museum.]

Description.—Corallum formed short, thick, irregular, rounded columns rising vertically, consisting of compact and freely fusing stems about 3 cm. thick and 5–6 cm. high. The tops divided into three or four erect, slightly pointed processes of different thicknesses and heights (up to 1·5 cm.) and shapes. These formed the beginnings of fresh clusters of erect fusing columns. The living layer extended some 6–7 centimetres, with its lower edges sometimes hanging free.

The calicles pit the altered surface, but are not deep, and measure from wall to wall 2–2·5 mm. across. The walls reticular, thick and dense. In section the calicles are 2 mm., but the finer structure is confused apparently owing to the fact that the skeletal elements were everywhere hollowed in the typical manner by some alga. Septa were of uniform thickness, short and irregular, fused very freely together, showing distinct traces of the typical formula, but they seem to be melted down with the large columellar tangle to form to the naked eye a reticulum not very distinct from that of the walls and without very marked radial symmetry.

There is only one complete specimen of this coral (11 cm. high) and a mounted transparent section. Here and there faint traces of septal formation can be seen on the surface; on the boring alga see p. 53, with footnote.

Branching Goniopores seem to have been common in this district. The only one closely described, *Porites ramosa* Reuss, thick beds of which are found at Crosara, differs from this in that its walls are thin single threads (see p. 110). The details of Catullo's *P. ramosa* are not sufficient for any identification (see p. 107).

a. Geol. Dept. R. 910.

* These nodules are probably the effects of aqueous action on the dead surface, see p. 113.

95. Goniopora Vicenza $_{(13)}$13.

[In the Michelotti Collection with an old label, "*Litharœa bellula* Montecchio" * (Oligocene?); Geol. Mus. Univ. Rome.]

Description.—Corallum so strongly convex as to suggest its being the tip of a round branch or stem, 18 mm. in diameter, tapering rapidly to a blunt point.

Calicles about 1·75 mm. across, shallow funnel-shaped, polygonal, with blunt rounded walls, which are a smooth, dense but angular reticulum, i.e. composed of smooth threads bent sharply at all angles. The same angular reticulum invades the calicle and obscures more or less completely its radial symmetry. Septa appear to be about 15–17, but very few of them run from the wall towards the centre, but end suddenly or else bend about to join one another or a directive at almost any angle. Here and there a typical triplet is seen, but no formula can be discovered. The texture of the section obscured.

I have seen no other Poritid like this. Its leading characters are (1) its apparently ramose corallum; (2) its close reticulum of smooth, angularly bent threads; and (3) the obscuration of the radial symmetry in its calicles.

In all these points it is in very striking contrast with Michelin's "*Astræa bellula*" (see p. 133), or with Milne-Edwards and Haime's "*Litharœa bellula*" (see p. 134).

96. Goniopora Verona $_{(2)}$1.

[Ronça (Upper Eocene).]

Porites pellegrinii, Reuss (*partim*), Denksch. K. Akad. Wiss. Wien, xxxiii. (1874) p. 14, pl. xl. figs. 9, 10.

This coral from Ronça was grouped with others from S. Giov. Ilarione (see *G. Vicenza 7*) as a species "*Porites pellegrinii*," by Reuss. According to our rule we have assumed that the description and figures apply primarily to the specimens from the latter locality, but, with such a careful worker as Reuss, it is fairly certain that there were very good grounds for grouping them together. On its possible relationship with the *Porites pellegrinii* of D'Achiardi see p. 108 and p. 112.

97. Goniopora Verona $_{(2)}$2.

[Ronça (Upper Eocene), coll. Michelotti; Geol. Mus. Univ. Rome.]

Description.—Corallum a small convex plate with edges folding under and built up of layers, so that if the object on which it started were small the coral might later form a nearly spherical mass by fresh layers.

* Unfortunately no information is given as to which Montecchio is meant, or from what horizon the specimen comes. One Montecchio is situated in the Quaternary beds which stretch along the valley of the Po, and the other is in Vicenza: this latter is probably that which is meant.

Calicles 3·5 mm. in diameter, polygonal, deep, with thin sharp walls. Septa thin and wavy, and apparently running in zigzag lines over the walls. The septal formula is obscure; here and there traces of the typical arrangement of tertiaries fusing with secondaries to make trident-shaped triplets between the primaries can be seen, sometimes with a keel joining two opposite secondaries, but the waviness of the lines makes them often difficult to follow. The edges seem to have been denticulate.

The original specimen of this coral was kindly lent by the Director of the Geological Museum of the University of Rome for the purpose of this Catalogue. It is apparently that recorded by Dr. Angelis, *Atti R. Accad. Lincei*, 1895, p. 178. An old label attached to it implies that it is specifically identical with *Astræa ameliana* of Defrance and Michelin, which is a fossil found in the Paris Basin (see p. 134). The only reason for this identification which I can find is that Milne-Edwards and Haime added the locality Ronça in their description of *Litharæa ameliana*, see Hist. Nat. Cor., iii. (1860) p. 188.

98. Goniopora Alessandria (3)1.

[Near Asti (Pliocene), coll. Michelin; ? Turin Museum.]

Porites collegniana, Michelin (*partim*), Icones (1840–47), p. 65, pl. 13, figs. 9 *a*, *b*.

This name was given by Michelin to a group of specimens from the environs of Asti and of Turin on the assumption that they belonged to the same species. The description of this species based upon Michelin's text and figures should have been given here, but will be found under *G. Turin 1.*

On Milne-Edwards and Haime's assertion that the "species" extended all over middle and south Europe, see remarks under the same heading. My own experience among recent corals leads me to believe that closely allied forms from localities even so near to one another as Turin and Asti would show structural variations which should not be ignored.

99. Goniopora Alessandria (3)2.

[Tortona (Miocene Tortonian).]

Litharæa diversiformis, Sismonda (*partim*), Pal. Terrain Tert. Piémont (1871), p. 25, pl. ix. figs. 1 and 2.

This coral was one which Sismonda grouped with one or more others from the "Mioc. moyen" of Turin, as belonging to one and the same species "*Litharæa diversiformis.*" The description given of this group will be found on p. 119, under the heading *Goniopora Turin 3.* The reason for making a separate heading for each recorded locality is explained in the Introduction, p. 35. The gravest doubts hang over the genetic groupings even of recent forms, the details of which can be closely compared. The difficulty of grouping fossils genetically is increased tenfold. Further, such a specific name as "*diversiformis*" is sufficient of itself to awaken suspicion.

100. Goniopora Alessandria (3)3.

[Stazzano, Novi Ligure (Miocene—Tortonian), coll. Michelotti; Geol. Mus. Univ. Rome.]

Description.—Corallum massive, very light and fragile.

Calicles from 1·75–2 mm., irregularly polygonal and shallow. Wall, a thin thread, slightly swollen here and there and irregularly bent, seldom evenly zigzag. When this edge is rubbed off, the wall is a reticulum of almost rectangular meshes, built up by a regular ring of synapticulæ joining the septa, and parallel with the wall thread. The septa are very irregular and start from the wall thread; they are smooth, thin, and swelling slightly at their tips, that is, if free. They usually meet a rather large central ring; several irregular triplets can be traced, which point to the typical formula. The number of septa seems to vary from 14–20.

In the vertical section the straight, thin trabeculæ are far apart and are joined together by parallel threads forming slight swellings where they meet the trabeculæ. The reticulum is very light and the meshes very large.

This coral with its open thread reticulum recalls the coral from Turin described on the next page as *G. Turin 2* and labelled "*Litharæa asbestella*" in the Geological Museum, Rome. There is, however, in this latter coral no trace of the synapticulæ running round inside the wall, and the septa are there much more wavy and irregular.

As this is unlike any form yet described, it is to be regretted that it was inconvenient at the time of my examination of it, to have it figured. See under *G. Turin 3*.

101. Goniopora Turin (3)1.

[Near Turin (Middle Miocene), coll. Michelin; Turin Museum.]

Porites collegniana, Michelin (*partim*), Icones (1840–47), p. 65, pl. 13, fig. 9 *a*, *b*.
? *Litharæa asbestella*, Sismonda, Pal. Terrain Tert. Piémont (1871), p. 25.

Description.—Corallum encrusting and forming rounded and lobate masses with smooth upper surface; single layers, apparently uniformly 3–4 mm. thick.

Calicles polygonal, crowded, shallow. Walls thin, ragged, granulated, and echinulate, upper edges of septa the same; both walls and septa very perforated. A small but rather conspicuous columellar tangle is shown in Michelin's figure.

The number of the septa shown in the magnified drawing given by Michelin shows that this was a *Goniopora*.

Milne-Edwards and Haime brought confusion into the record by identifying it with a coral which had been called by Defrance *Astræa incrustans*, but which according to these authors was a *Porites*. I can find no description by Defrance of any such coral, nor is it possible to ascertain whether Milne-Edwards and Haime were referring to an actual fossil or to Michelin's coral, or, if the former, whether it was a true *Porites* or a *Goniopora*. The fact

that they give Turin as the first locality makes one think that they were referring primarily to Michelin's coral. In that case all the facts have been confused by their arbitrarily changing the name. Instead of it being a fossil from Turin we have it stated that it occurs also at Bordeaux, Dax, at the mouth of the Rhone, and, quoting Reuss, in Bohemia, round Vienna, in lower Austria, Hungary, and Moravia. There is no way out of this confusion except by going back to ascertainable facts. These are as follows:—Michelin figured a *Goniopora* from Turin (or perhaps from near Asti), and he believed it was the same fossil which Michelotti had mistaken for a sponge and had called *Tethia asbestella.** Sismonda having re-examined Michelotti's "sponge," pronounced it to be a *Litharæa* (= *Goniopora*) which formed masses sometimes encrusting but thick, with nearly round calicles and septa thin and few in number. This description does not agree very well with Michelin's figure. We have then only Michelin's own figure and description to deal with. According to our rule we assume that these apply primarily to the specimens found at the locality first mentioned, that is, in this case, Asti. This description should therefore have come under *Goniopora Alessandria 1.*

102. Goniopora Turin $_{(3)}2$.

[Turin (Middle Miocene), coll. Michelotti; Geol. Mus. Univ. Rome.]

? Litharæa asbestella, Sismonda, Pal. Terrain Tert. Piémont (1871), p. 25.
Litharæa asbestella (*pars*), Angelis, Atti R. Accad. Lincei (1895), p. 178.

Description.—Corallum forms large solid masses.

The calicles 1·5 mm. across. The skeleton is very open and the septa not at all symmetrically arranged. They are short,† hardly ever free, and meet irregularly in pairs, but whether meeting or single they abut upon a straggling, often almost polygonal, columellar ring. There appear to be only 12, but there are signs of some of them forking near the wall, and further, the fusions show no trace of the formula typical of *Porites.* The wall threads are quite straggling and irregular, of the same thickness as the septa. The interseptal loculi very large, open, and angular. The very irregular angular reticulum of the surface with its large open meshes is in strong contrast with the rows of regular trabeculæ running vertically through the mass of the coral and separated by rows of large pores.

This is the description of a large fragment of a block which had been rolled into a pebble 6 cm. thick, belonging to the Michelotti Collection in the Geological Museum in Rome. It is labelled "*L. asbestella* Helvetian, Colli di Torino." It is nothing like the *P. collegniana* of Michelin (see synonymies of Michelin and Sismonda), nor is there anything in Sismonda's text which could possibly help towards its identification with his *asbestella.*

The specimen has a strong resemblance in skeletal structure to that from Stazzano (see *G. Alessandria 3*).

* Spec. Zoophytolog. diluvianæ, Turin, 1838, p. 218.

† Sismonda comparing his "*L. asbestella*" with "*L. diversiformis,*" says, the septa of the latter form, which he figures as long and tapering, are shorter than those of the former.

103. Goniopora Turin (3)3.

[Turin (Middle Miocene).]

Litharœa diversiformis, Sismonda (*partim*), Pal. Terrain Tert. Piémont (1871), p. 25, pl. ix. figs. 1 and 2.

Original Description (which was applied to a group of specimens from different localities; see also *G. Alessandria 2*).—Corallum forms irregularly humpy or lobate masses.

Calicles very small, average about 1 mm., less deep than they are wide, pentagonal. Septa " 12 " [in figures as many as 17], thick but not crowded, secondaries differing but slightly from the primaries. Columella spongy, not rising as a prominence in the base of the calicle.

This description does not agree well with the figure in which the septa are long and thin, as many as 17 in number, and apparently with toothed edges. Sismonda gives two localities: Turin (mioc. moyen) and Tortona (mioc. sup.). This shows that he had at least two specimens which he put together under this name. It is possible, therefore, that the specimen he described was a *Porites* with " 12 " septa while the one he figured was a *Goniopora*.

I have been permitted by the courtesy of Professor Portis to examine three specimens from the Michelotti Collection, Rome, labelled "*L. diversiformis* Michelotti (Tortonian, from Stazzano)"; but two of them are *Porites* and distinct from one another, and only one is a *Goniopora* distinct from the one figured by Sismonda; and here described as *Goniopora Alessandria 3*.

104. Goniopora Genoa 1.

[Dego (Upper Oligocene); Turin Museum.]

Porites incrustans Def., Michelotti, Études Miocène Inf. (1861), p. 49 (*pro parte*).
Litharœa ponderosa, Sismonda (*partim*), Pal. Terrain Tert. Piémont (1871), p. 26.

Original Description (which was applied to a group of specimens, cf. also *G. Genoa 2*). — Corallum massive, upper surface convex, lower surface nearly flat.

Calicles not very deep, subpolygonal, and with " simple " walls, 2–3 mm. across.

I can find no further description of these corals said to come from Dego and also from Sassello thus briefly referred to by Sismonda. They were apparently the same as those Michelotti grouped under the name " *P. incrustans* Defr.," for the author tells us in his preface that Michelotti placed his palæontological collection at his disposal. Dr. Angelis,* who has given an account of the Michelotti Collection in the Geological Museum of the University of Rome, mentions three *Gonioporæ* from Dego and three from Sassello. One of the former, viz. his *Litharœa oblita*, is, I believe, an Astræid. As he seems to make no mention of any *L. ponderosa*, the specimens named by Michelotti *P. incrustans* and renamed by Sismonda are probably preserved in some other Italian museum.

A careful comparative study of the rich *Goniopora* material in the Italian Museums is certainly a desideratum, provided the results are not confused by any premature attempt to group the specimens into species.

* Atti della R. Accad. dei Lincei (5°) i. 1895.

105. Goniopora Genoa (5)2.

[Sassello (Upper Oligocene).]

Litharæa ponderosa, Sismonda (*partim*), Pal. Terrain Tert. Piémont (1871), p. 26.

Description.—Certain *Gonioporæ* from Sassello were grouped with others from Dego as a "species." Believing all such grouping to be premature we return here to the simple facts. The original description applied to this group will be found under the last heading (see p. 35 of Introduction).

106. Goniopora Genoa (5)3.

[Sassello (Upper Oligocene); Geol. Mus. Univ. Rome.]

Litharæa michelotti (Meneghini in litt.), Angelis, Atti R. Accad. Lincei (5°) i. (1895) p. 180, fig. 9 in text.*

Description.—Corallum a flat expanding growth; 7 cm. across and varying from 1 to 1·5 cm. in thickness; surface smooth and very slightly wavy.

The calicles are very uniformly 1·5 mm. across, appear to have been very shallow, crowded, with walls too irregular to be strictly polygonal. The walls simple, incomplete, very irregular, often so wavy that together with the bases of the septa they form a reticulum which is here and there even thick, but only faintly raised above the surface and apparently without any sharp median ridge.

The septa are short, 12 appear to meet the large columellar tangle. But the typical septal formula of *Goniopora* is clearly visible, the tertiaries fusing in pairs with the secondaries, but in such a way that it looks as if the secondaries forked near the wall (cf. Diagrams A and B, p. 21). The septa thus appear very wavy and irregular. The interseptal loculi and the spaces in the columellar tangle are large and open, and the whole skeleton is light and porous.

There is reason to believe that the specimen had been altered by postmortem aqueous action before fossilisation, for the skeletal elements of the surface are thicker than those in the section and the points and projections are smoothly rounded off, as is usual with corroding corals. The specimen has been recently described by Dr. Angelis, and the name given by him was that found on the label in the handwriting of Professor Meneghini. The specimen is particularly interesting because, though it is a *Goniopora*, the tertiary septa are so small and fuse with the secondaries so near the wall that we have very nearly the condition which we have figured in the Introduction, p. 21. This is not shown in Dr. Angelis' figure, as the method of illustration adopted, which is now very commonly used to illustrate fossil corals, is not adapted for elucidating details of structure.

* Examination of Dr. Angelis' original preparations, most kindly placed by him at my disposal, shows that the clichés of his figs. 8 and 9 were accidentally transposed by the printers.

107. Goniopora Genoa (5)4.

[Dego (Upper Oligocene), coll. Michelotti; Geol. Mus. Univ. Rome.]

Rhodaræa ambigua, Angelis, Atti R. Accad. Lincei, i. (1895) p. 181 (text fig. 8).*

Description.—Corallum massive, complete form unknown, there being only a single pebble-shaped specimen with calicles much obscured.

Calicles all sizes owing to intercalicular budding, up to 7 mm. Septa about 24, thin and straight near the walls, but greatly interrupted by perforations, and also much bent near the axis (the hook-like curl in the figure is certainly delusive). The formula is difficult to make out; traces only of the typical arrangement can be seen in the section, but I have failed to find any symmetry in the calicles exposed at the surface. The columellar tangle seems to have been very irregular, with a good many angular nodules.

The section of this coral (prepared by Dr. Angelis and kindly lent me for examination) shows that it is a true *Goniopora*. One of the chief points of interest are the large calicles.

There is only one specimen from this locality in the British Museum Collection which might possibly be identified with the above. It looks like a Poritid, but is now so altered internally that the sections show no trace of structure.

a. Geol. Dept. R. 3642.

108. Goniopora Genoa (5)5.

[Dego (Upper Oligocene), coll. Michelotti; Geol. Mus. Univ. Rome.]

Litharæa pulvinata (*partim*), Angelis (*non* Michelotti †), Atti R. Accad. Lincei, i. (1895) p. 179.

Description.—Corallum a thin, nearly circular plate with very sharp edges, closely encrusting, upper surface slightly wavy and convex.

Calicles about 2 mm. across and less, depressed, with raised blunt but well-marked walls. The walls are mostly simple threads and appear thickened where the septa abut against them close to their margins; here and there, however, they form a few independent reticular meshes, e.g. in raised angles where new buds would have formed. The general appearance of the septal formula is not unlike that drawn by Michelin for his *P. collegniana* (Icones, pl. 13, fig. 9; see also above, p. 117), but close examination shows quite clearly the typical formula, the tertiaries being short and bending quickly round to fuse with the secondaries. In the smaller calicles parts of this formula are confused. The epitheca is wrinkled, except where it was closely adherent to the substratum. The meeting of septa in the centre is very irregular so that no conspicuous columellar tangle is formed. There appears at times a prolongation of a septum like a directive.

The specimen to which this description applies is one of those referred to by Dr. Angelis, and was kindly lent by Professor Portis for examination. It belongs to the Michelotti Collection

* See footnote on the preceding page.

† Études Miocène Infer. (1861), p. 158, pl. xv. figs. 3 and 4.

in Rome, and has an old label, "*Litharæa pulvinata.*" It is, however, quite different from Michelotti's figured type of *L. pulvinata* (*l. c.*) which is not easy to understand: for while the growth-form is that of a *Goniopora*, the striæ running from calicle to calicle are not typical of *Goniopora*; cf., however, the calicles shown on Pl. IX. fig. 3. On the other hand, it should be noted that Sismonda accepted Michelotti's figure as that of a true *Litharæa* (= *Goniopora*) and remarked on the large size of the calicles (Pal. Terrain Tert. Piémont, 1871, p. 26).

The encrusting, almost primitive growth-form of the coral here described is very different from that of Michelotti's figured type.

Group VIII.—AUSTRIA-HUNGARY.

Containing notices of Poritids, many of which were certainly Gonioporæ, from the following localities.

Specimens described and figured from—

(*a*) Pötzleindorf, Vienna.
(*b*) Stockerau, Lower Austria.
(*c*) Niederleis, „ „
(*d*) Forchtenau, Hungary (near the Austrian border).
(*e*) Neustift, near Oberburg, Styria (2 forms).
(*f*) Koritzan, Bohemia (2 forms).
(*g*) Bilin, Bohemia.

In addition to these:—

Poritids said to be of the same "species" as that described and figured from (*a*) are recorded from Enzesfeld in the Leithakalk in Austria; Rudelsdorf, near Landskron in Bohemia, in the Tegel; Mattersdorf in Hungary; and at Kostel in Moravia.

Poritids said to be of the same "species" as that described and figured from (*c*) are recorded from Nodendorf, Porzteich, and in the Muschelberg near Nikolsburg in Moravia.

Poritids said to be of the same "species" as that described and figured from (*d*) are recorded from Pötzleindorf, Grund, Enzesfeld, Niederleis, Nodendorf, Kalladorf, in Austria; Mattersdorf in Hungary; Nikolsburg and Kostel in Moravia; in the Leithakalk of St. Nicholai and Gamlitz in Styria.

A Poritid said to be of the same "species" as one of two described and figured from (*e*) is recorded from Gradische, also near Oberburg.

A Poritid said to be of the same "species" as one of the two described and figured from (*f*) is recorded from Přemyšlan.

There have thus been as many as 29 finds, mostly from separate localities, but we have only nine descriptions, a result almost entirely due to the custom of "making species."

109. Goniopora Vienna Basin (4)1.

[Pötzleindorf, Vienna (Miocene [Tegel-sand = Tortonian]); Vienna.]

Porites collegniana, Reuss (*partim*) (*non* Michelin), Naturwiss. Abh. von Haidinger, ii. (1848) p. 28, pl. v. fig. 3.

Description.—Corallum forms irregularly rounded or lobate masses. Calicles small,

crowded, polygonal, walls slightly raised, sharp, ragged, and echinulate. Septa very perforate and also with ragged edges. A wart-like central columella. The vertical section shows a reticulum consisting of diverging trabeculæ with rows of intervening meshes.

The figures which illustrate this description (of a group) are fortunately those of a specimen from a definite locality, Pötzleindorf, and we have therefore to deal with this alone. Reuss' identification of it with a number of other Poritids not only from within or bordering on the Vienna Basin, but even with one from Turin, is no longer of any help to us.

In 1871, under the influence of the works of Milne-Edwards and Haime, he proposed to make this a synonym of the *Astræa incrustans* of Defrance, on which see the observations on p. 117.

The simple facts are that we have a description and a figure of a Poritid from Pötzleindorf in the Tegel-sand. We gather that this is a *Goniopora* from the fact that the freely fusing septa frequently fork near the walls; on the significance of the forking septa see Introduction, p. 21.

The other localities in Austro-Hungary from which Reuss records the remains of Poritids which he believed to be of the same species are,—Rudelsdorf near Landskron in Bohemia, in the Tegel; Enzesfeld, Lower Austria, in the Leithakalk; Mattersdorf in Hungary; and at Kostel in Moravia. A re-examination of these Poritids is a desideratum.

110. Goniopora Vienna Basin (4)2.

[Waschberge near Stockerau (Miocene [Tortonian]); Vienna Museum.]

Porites leiophylla, Reuss, Naturwiss. Abh. von Haidinger, ii. (1848) p. 28, pl. v. fig. 4, *a*, *b*.

Description.—Corallum with smooth, convex upper surface, from 2·5–5 cm. across.

The calicles quite irregular and flowing together, without raised walls, judging from the exposed surface which may have suffered from post-mortem corrosion; wherever the walls form a network it is very large meshed and irregular.

The septa, 15 to 20 in number, are thick (thicker in proportion than in the original figure 4 *b*), but unequal both in thickness and length, smooth, wavy, and fusing irregularly. The interseptal loculi are very irregular in shape and size owing to the fusions and to the occasional presence of synapticulæ. Hardly any septa end freely, but all meet a small columellar tangle, which may be merely a ring consisting of a smooth, nodulated, rather thick thread.

As there are usually from 15–20 septa this coral must be regarded as a *Goniopora*. It is a very interesting form, for it not only shows a tendency of the skeleton to melt down into a fluent reticulum, but the fusions of the septa at *varying* distances from the wall leave no doubt but that the forking abutment of septa close against the wall really represents two septa fused together. Cf. Introduction, p. 21, on the origin of *Porites* from *Goniopora*.

In 1859, Dr. Abich* referred some Poritids found in the valley of the Araxes to "*Litharæa leiophylla* of Reuss," and described a rich collection of Poritids from the islands in

* Mem. Ac. Imp. Sci. St. Petersburg, ix. pt. 1 (1859); see pp. 76 and 101.

Lake Urmi as belonging to the same "species." In addition to the primary improbability of two forms so far apart being so exactly similar, there are further reasons for doubting the validity of this interpretation, reasons based upon the difficulty of interpreting the fossils. See on this point pp. 96–98.

Reuss records (*l.c.*) a "third species like *P. deshayesiana* Mich." (which is a true *Porites*) from the same hard limestone, but the details could not be made out.

111. Goniopora Vienna Basin (4)3.

[Niederleis, Lower Austria (Miocene [Tortonian]); Vienna Museum.]

Porites leptoclada, Reuss, Fos. Cor. Öst-Ung. Miocäns in the Denkschr. K. Akad. Wiss. Wien, xxxi. (1872) p. 261, pl. xvii. figs. 3 and 4.

Description.—Corallum presumably dendroid, the branches forking at a somewhat blunt angle; only cylindrical fragments of stems and short portions of branches, frequently compressed, were discovered.

On the older portions the calicles are shallow, crowded, polygonal, 1·5–2 mm. in diameter, and marked off from one another by rows of coarse flattened grains. Twelve short, thick septa with edges composed of from 2–4 similar granules, and their sides covered with sharp points. In smaller calicles the pali can hardly be distinguished from the septa, but elsewhere they form a ring of 5–6 moderately large grains, with a very small central tubercle often deep down.

On younger compressed branchlets the walls, though not high, rise into ridges with rather sharp edges.

This coral is said to be very common at Niederleis and "also at Nodendorf"; and the same is said to occur rarely at Porzteich and on the Muschelberg near to Nikolsburg (Moravia). The one figured by Reuss is from the first-named locality in the Vienna Basin, and we must confine our attention to it.

It might be interesting to inquire whether, considering the close similarity of these intracalicular skeletons, this dendroid form might not be a branching tuft-formation of the same coral whose encrusting stages are described under the last heading. The type of calicle was that still found on branching *Gonioporæ*. That encrusting forms may easily pass into tufts we have already seen: compare, for instance, *G. Great Barrier Reef 1* and *12*.

112. Goniopora Vienna Basin (4)4.

[Forchtenau near Ödenburg [west of the Neusiedler See] (Miocene [Tortonian]); Vienna Museum.]

Porites incrustans, Reuss, Fos. Cor. Öst.-Ung. Miocäns in the Denkschr. K. Akad. Wiss. Wien, xxxi. (1872) p. 261, pl. xvii. figs. 5 and 6.

N.B.—It would have been doubtful how far the following description referred to an actual specimen or was modified by reference to the description of the "Porites incrustans Def." (which may have been based upon Michelin's *P. collegniana*, see p. 117) of Milne-Edwards and Haime, had not the figures been clear and good, and had it not been expressly stated that the specimen figured was from Forchtenau.

Description.—The corallum irregularly humpy, even with lobate knobs which frequently appear as if built up of successive layers.

The calicles 1·2–1·5 mm. in diameter, polygonal, variable, shallow, and separated by a low ridge which is often curved, indented and echinulate; in each calicle 11–14, usually very thin, nearly uniform septa, which are perforated and beset along the edges and on the sides with sharp points. Five to seven pali which are irregular, sharp-pointed granules and only differ from the points on the edges of the septa in size and height. A small central tubercle often sunk down below the surface.

Vertical trabeculæ are conspicuous in the section, and joined by short horizontal pieces making a nearly symmetrical reticulum with roundish meshes.

We can add to the above description the fact that many of the septa fork near the walls, as is shown in the figures. This, according to the line of argument here adopted (see Introduction, p. 21), shows that the coral belongs to this genus. The septa are thick and wedge-shaped, and the wall is a single ring of synapticulæ apparently not arranged in a zigzag. The next form seems to have had the same type of intracalicular skeleton, and to have differed mainly in growth-form.

In addition to finding this specimen at Forchtenau, Reuss mentions having seen Poritids which he took to be of the same "species" at the following localities:—

Rudelsdorf (Bohemia); Pötzleindorf, Grund, Enzesfeld, Niederleis, Nodendorf, Kalladorf; from Mattersdorf (Hungary); Nikolsburg, Kostel (Moravia); in the Leithakalk of St. Nicholai and Gamlitz (Styria). In the hard limestone it is only recognisable by its skeletal structure. It is abundantly imbedded in the "Leithakalk des Rauchstallbrungrabens bei Baden." While outside Austria, Reuss not only gives the localities mentioned by Milne-Edwards and Haime (see above, p. 117) but adds Sogliano al Rubicone (Prov. Forli), Bianchi near Messina (frequent but badly preserved), Isl. of Rhodes, etc.

While I should hardly like to say that it is impossible for one and the same coral form to be spread so widely without many striking variations in structure, my experience justifies me in refusing to believe in the existence of such a species. It cannot be accepted and it cannot be denied. The little evidence we can get, namely, from comparing Michelin's figure of his *P. colleyniana* with Reuss' figures of this coral, seems to me more than enough to make it imperative to return to the barest facts.

113. Goniopora Oberburg (2)1.

[Neustift, Oberburg, Styria (Oligocene).]

Porites nummulitica, Reuss, Denkschr. K. Akad. Wiss. Wien, xxiii. (1864) p. 28, pl. viii. figs. 7 and 8.

? *Porites nummulitica*, Reuss, Denkschr. K. Akad. Wiss. Wien, xxviii. (1868) pp. 164, 167, 170 and 175.

? *Porites nummulitica*, Reuss, Denkschr. K. Akad. Wiss. Wien, xxix. (1869) p. 250.

Description. — Corallum apparently branching, cylindrical or slightly compressed, 12·5 mm. thick.

Calicles 2 mm. across, conspicuous, shallow, separated by low not very sharp walls; septa 12–18, narrow, irregular, free edges sharply granulated, mostly fusing, so that only 6–9

reach the centre; pali six, small, equal, grain-like, not very distinct, and surrounding a small columellar tubercle.

With a lens the whole surface appears to be strewn with granules.

This is another form which approaches *Porites* in habit. But the septa are too numerous. They do not reach the columella, at least along their uppermost edges. The pali rise distinct from the ends of the septa. In the figure they are eight in number, not six as stated in the description.

A Poritid, apparently similar to this, hence called by Reuss by the same name "*nummulitica*," was found at Gradische, also near Oberburg; while the same "species" was said * to occur in the Tertiaries of Vicenza (Monte Castellaro, Monte Grumi, and other places round Castel Gomberto).

Further, in a still later work (op. cit., xxix. (1869) p. 250) the same "species" was extended to take in another form still, in spite of its showing differences in growth-form and in the size of the calicles: see *Goniopora Vicenza 4*.

114. Goniopora Oberburg (2)2.

[Neustift, near Oberburg, Styria (Oligocene.)]

Litharæa lobata, Reuss, Denkschr. K. Akad. Wiss. Wien, xxiii. (1864) p. 28, pl. viii. fig. 9.

Description.—Corallum (form unknown) probably "Lappig-ästig."

Calicles 2·5–3 mm. across, quite shallow, hardly depressed. Walls often thread-like and wavy, hardly traceable and often incomplete.

Septa 18–20, irregular, crowded and fusing together in pairs and triplets, also united by synapticulæ; none are seen to end freely, all either fuse together or run into the large central tangle. The interseptal loculi are small.

This form is very distinct from the other *Goniopora* found in the same locality (see last heading); only in growth-form does it seem to correspond, but both are irregular fragments which tell little about the original shape. Reuss speaks of it as being probably "lappig-ästig."

For Milne-Edwards' "*Goniopora lobata*" see p. 100.

115. Goniopora Koritzan (2)1.

[Koritzan, Bohemia (Upper Cretaceous [Cenomanian]); Prague Museum.]

Porites Michelini, Reuss, Verst. Böhm. Kreideformation (1845), p. 61, pl. xliii. fig. 3.
Porites Michelini, Posta, Anthozoen Böhm. Kreideformation, Abh. K. Böhm. Ges. Wiss., ii. (1887) p. 26, pl. i. figs. 4, *a*, *b*.

Description.—Corallum forms irregular rounded masses, often nearly globular, from 3–15 cm. in diameter, with edges at somewhat regular distances round the often tall and gradually thickening base, round which fragments of epitheca occur.

* Op. cit. (1868).

Calicles "small," very shallow, "irregularly separated by level cœnchyma from which they are not separated by distinct walls." In other words, the walls are a level reticulum of irregular thickness. Septa 12–14–16–18 or 24, rather thick, straight or slightly wavy, with irregular synapticulæ projecting from their sides often joining the septa; the inner ends of the septa when not fused together are rounded, and often bent up and then not distinguishable from the "pali." These pali seem to be rather the free ends of the columellar tangle; they are quite irregular in size, number, and arrangement.

The most important point about this coral is that it is a cretaceous fossil, and therefore one of the earlier known *Gonioporæ*. There can, I think, be little doubt but that it is a Poritid. The simple growth-form, like a series of caps fitting over one another with a succession of edges; the number of septa; the fact, brought out clearly in both figures, that the septa fused together *; are enough to establish it as a member of the genus.

Reuss speaks of it as being rare in the Hippuriten-Kalk near Koritzan, Bohemia. While Posta says it occurs (not rarely) in the Cenomanian strata of Koritzan and of Přemyšlan, and that the specimens are found of all sizes.

116. Goniopora Koritzan $_{(2)}$2.

[Koritzan, Bohemia (Upper Cretaceous [Cenomanian]); Prague Museum.]

Porites textilis, Posta (*partim*), Anthozoen Böhm. Kreideformation, Abh. K. Böhm. Ges. Wiss., ii. (1887) p. 27.

This is one of two corals described by Posta under one name. For the description of the form which was figured, see *Goniopora Bilin 1*. It does not appear to differ very much from *G. Koritzan 1*.

Another coral, called by Posta *Porites spissus*, from this locality, does not seem to me to be a Poritid at all on account of the character of the wall, as shown in his published figure, *l.c.* pl. i. fig. 5 *a* and *b*. Such a perfectly regular costal wall I have never yet seen in any member of the family. But both text and figure are difficult to interpret.

117. Goniopora Bilin $_{(1)}$1.

[Bilin, Bohemia (Upper Cretaceous [Cenomanian]); Prague Museum.]

Porites textilis, Posta (*partim*), Anthozoen Böhm. Kreideformation, Abh. K. Böhm. Ges. Wiss., ii. (1887) p. 27, pl. i. fig. 6.

Description.—Corallum forms irregular nodules up to 12 cm. round, sometimes narrowing towards the base, stock consisting of concentric layers.

Calicles polygonal, wall frequently incomplete; the wall-cœnchyma seems to be thinner and less developed than in *Goniopora Koritzan 1*, and at the same time more reticular. Septa

* In describing his *Porites textilis*, the author definitely states that the septa in his *Porites Michelini* are branched, *l.c.* p. 28.

18–20, fusing together and wavy with lateral synapticular projections, sometimes joined together by them; a small columellar tangle; 3–6 irregular ridge-like pali.

This form seems not to differ from *G. Koritzan 1* in any essential; what differences there are seem to be mainly of degree. Those noted by Posta are (1) the septa are more continuous and are branching; (2) there is a more regular wall-reticulum, "cœnenchyma"; (3) fewer pali rise from the columellar tangle; and (4) the calicles are a little nearer together.

The specimen figured is from Bilin; a second specimen of the same coral is said to have been found at Koritzan, see *G. Koritzan 2*.

Group IX.—FRANCE.

Containing descriptions of Fossil Gonioporæ from Dax (1–4); *Gironde* (1–2); *Paris Basin* (1–14); *Coutances* (1–2); *and one from some unknown locality in France.*

Note.—These divisions are very far from satisfactory—they are not at all uniform. Dax is an arrondissement, and is kept because it is familiar to palæontologists. The next name, "Gironde," is a department, and two specimens are included, one labelled simply "Gironde" and the other from "near Bordeaux," and therefore in the arrondissement Bordeaux. But the first name may mean the department Gironde, or the town, which is in the arrondissement La Réole. Owing to this uncertainty the two localities must be covered by Gironde the departmental name. Coutances is again an arrondissement. These are all political divisions, and in contrast with them we have the "Paris Basin" as a geological area, overrunning a number of political divisions. One would have been glad if there could have been more uniformity, but while this is an instance of the chief difficulty in the working out of this system, it will also make it clear how little real harm is done. For no subsequent improvements in these names can ever really confuse. An improved designation will be obviously and not arbitrarily synonymous, being merely a different way of indicating one and the same locality.

For observations on the peculiar morphological specialisation of the French *Gonioporæ* see note at the end of the Group, p. 145.

118. Goniopora Dax (4)1.

[Dax (Miocene [Burdigalian]); Paris Museum.]

"*Litharæa ramosa*," M.-E. & H., Monogr. des Poritides (1851), p. 38. Said to have been in the "Collection Michelin."

Description.—Corallum dendroid, with cylindrical divergent branches, ca. 1 cm. thick. Calicles 2–3 mm. across, polygonal, slightly oblique, and better developed in the upper parts of the stock, nearly uniform, with thin simple walls. The calicles are 0·5 mm. deep. The septa are said to be 12 in number and thin and nearly uniform, but before reaching the walls they thicken and fork ("géminées en dehors").

In spite of the statement that there are only 12 septa, the added fact that they are often "géminées en dehors" shows that the real number was greater. On this forking of the septa near the walls, see the Introduction, p. 21, where it is regarded as a vestige of the typical septal formula for *Goniopora*.

There are, unfortunately, no figures illustrating the coral. The "dendroid" growth-form is interesting; branching and tufted *Gonioporæ* are known, but none of them could be called "dendroid."

In 1859, Dr. Abich * described a form from Bajazid in the Araxes Valley as "Litharæa ramosa M.-E. & H." I have discussed, on p. 97, what I think to be a wrong interpretation of this fossil.

There are no branching Goniopores from Dax in the British Museum.

119. Goniopora Dax $_{(4)}$2.

[Dax (Miocene, Burdigalian).]

Rhodarœa raulini, Milne-Edwards and Haime, Polyp. Foss. des Terrains Pal., p. 145 (1851); also Hist. Nat. Coralliaires, iii. (1860) p. 184.

Description.—Corallum massive, moderately thick, with nearly flat top or only slightly convex; well-developed epitheca.

Calicles subcircular, 5–6 mm. across and 2 mm. deep. Walls thick with a light furrow running along their tops. Three complete cycles of septa, which are moderately thin where they join the wall (extérieurement), crowded, sublamellate, rising slightly above the walls. Six very large prominent pali "in front of the secondary septa."

This is Milne-Edwards' description of a *Goniopora* from Dax. The growth-form is not clear from the description. Both the fragments of fossil *Gonioporæ* from Dax in the British Museum are massive. One has very minute calicles; the other, a worn pebble, has calicles 4 mm. across, and may possibly be related to this form. Its reticular walls, however, show no traces of any structure which would suggest their having had a median furrow at the surface. A median furrow does occasionally occur in this genus, see p. 50, and Pl. II. fig. 3.

See also Introduction, p. 21, on the pali being in front of the secondary septa.

120. Goniopora Dax $_{(4)}$3. (Pl. IX. fig. 4.)

[St. Paul-les-Dax, France (Middle Eocene), coll. Deshayes; British Museum.]

Description.—Corallum massive, but growth-form unknown.

Calicles 4 mm. across. Walls rather thick, of a close reticulum, frequently flaky and with small pores, which contrast with the larger interseptal loculi. Septa only slightly wavy, arranged in the typical formula; the tertiaries often joining the secondaries at very blunt

* Mem. Acad. Imp. Sci. S. Petersburg, (6°) ix. pt. i. (1859) p. 103.

angles. The primaries and secondaries short because they so soon join the columellar tangle; very unevenly perforated, here nearly laminate, there very porous. The columellar tangle very large and flaky. Interseptal loculi large and rounded. In the vertical section the lattice-work of the vertical trabeculæ and the horizontal synapticulæ very regular and with large open meshes. An immense number of very delicate tabulæ or dissepiments.

The single specimen is half of a worn pebble-shaped fossil. The original surface is gone, and no clue is given as to the character of the walls at the surface. It is a typical *Goniopora*, and not unlike the form from Peloua, see *G. Gironde 1*. It is, however, altogether more reticulate and delicate, with more distinctly porous walls, and the calicles are smaller. Two other forms from Dax are described above: one was said to be dendroid and the other had very large calices, 5–6 mm., and large pali. The specimen that we are discussing looks as if it may have had pali, but, as stated, the original surface is worn away and the section can hardly be trusted to give definite information on that point.

The specimen is quite typical and does not show any of the extreme modifications of the majority of the Paris Basin forms.

a. Geol. Dept. R. 4814.

121. Goniopora Dax $_{(4)}$**4.**

[Gaas (Oligocene, Aquitanian), coll. Deshayes; British Museum.]

Description.—Corallum massive and very dense.

Calicles very minute, about 1·20 mm. Walls an open, very angular reticulum, of varying thickness. The septa vary in number, often appearing to be only 12, but so many of these fork before reaching the wall reticulum that there can be no doubt but that the true number is 18–20. The septa, which are not crowded, are angularly bent rather than curved, and frequently with lateral points here and there, which make the angular character of the septa more pronounced. The interseptal loculi are open and conspicuous. The columellar tangle is composed of the angularly bent ends of the septa fusing to form a rather solid reticular mass.

In the section the vertical trabeculæ are conspicuous in the walls, but the rest is a close reticulum with round pores and very thin filaments or flakes.

There is only a small fragment of this coral, without any trace of the original surface. It somewhat approaches those specimens which, but for the forking of the septa, would have to be placed in the genus *Porites*. See Introduction, p. 21, and for examples, *G. Gironde 1*, *G. Paris Basin 11*, and *G. France a* (Table IV. G, p. 182).

Geol. Dept. R. 4815.

122. Goniopora Gironde $_{(2)}$**1.** (Pl. IX. fig. 5; Pl. XIV. fig. 8.)

[Gironde (Oligocene, Aquitanian).]

Description.—Corallum massive, exact growth-form unknown.

Calicles 1·5 mm. across, polygonal, shallow, funnel-shaped, with sharp thread-like ridge along the wall; ridge straight or nodulated, wavy and even finely zigzag.

Within the wall and distinct from it are seen 12 radiating portions of the septa as short crisp plates, with jagged edges round the centre. Peripherally they run into a reticulum, which is composed of the forkings and fusions of the septa before they abut against the wall. There are thus, in reality, 18–24 septa, some free and others fused, when counted close against the wall-ridge.

The apparent peripheral ends of the 12 central plates frequently send out T-pieces, which tend to unite to form a synapticular ring round the fossa, and are the points of fusion of the tertiaries. An open columellar tangle fills the base of the fossa, and from it an irregular ring of pali with a central tubercle arises, but the ring, though frequently consisting of five points, is seldom regular or symmetrical, and the relations between septa and pali are very irregular.

In the sections, both transverse and longitudinal, the calicles can be traced through the stock. The reticulum is delicate, and shows a tendency for the horizontal elements to be flaky while the vertical trabeculæ are continuous and thread-like.

This form from Gironde is very like some of the extreme forms of the Paris Basin; forms which look at first sight exactly like *Porites*, but which have a columellar tangle, and when the notches in the walls are counted, show that there were more than 12 septa (cf. *G. Paris Basin 11*, and Table IV. G, p. 182).

There are two very beautifully preserved specimens, but unfortunately their original surfaces are rubbed off. They are obviously the same coral, and are of no small morphological importance in the genus; for they show the meaning of the forking abutment of many of the septa against the wall, viz. that the true number is 24, and that the 12 radial plates round the centre are merely the inner ends of the septa, perhaps the homologues of the pali, rising at the points of septal fusion. I can see no argument against this interpretation, and if correct, this septal system is a modification of the typical formula of *Goniopora*. The smallness of the calicles increases the resemblance of the coral to a *Porites*.

As stated in the observations to the Paris Basin specimens, it is possible that the filling up of the fossa with a close septal reticulum may be a protection against sand or mud, a deposit of which might easily weigh down the delicate skin into the skeletal interspaces, if the latter were large.

Specimen *a* (R. 2185) has two small portions of original surfaces in which the wall-thread, and the jagged edges of the septa, are perfectly preserved. One of these has been photographed on Pl. IX. fig. 5.

Both specimens show the borings of molluscs, the shells of which are still visible in *a*.

a. Labelled *Astræa Ellisiana* Def. Geol. Dept. R. 2185.
b. „ *Porites incrustans* Def. „ „ R. 2184.

123. Goniopora Gironde $_{(2)}$**2**. (Pl. IX. fig. 6; Pl. XIV. fig. 7.)

[Peloua, near Bordeaux, Gironde (Lower Miocene, Burdigalian); British Museum.]

Description.—Corallum massive, growth-form unknown.

Calicles average about 5 mm. across, with a few larger up to 7 mm., buds of all sizes between. Walls of nearly regular thickness, over 1 mm., of stout very flaky reticulum, not unlike the interstitial tissue of a *Favia*, except that the walls are perforate. Septa in the adult calicles have the typical formula; a few additional septa appear in the very large calicles obscuring the arrangement. The septa are laminate, and only slightly perforate, not so wavy as to prevent the radial symmetry from being conspicuous. The tertiaries may end freely or else bend round sharply to fuse with the secondaries about half-way between the wall and the columellar tangle, which is a coarse, open, and quite irregular reticulum.

Numerous tabulæ, frequently arranged so as to show that the floor of the calicle cavity was convex. They are so strongly marked as to remind one of the vesicular tissue of many Palæozoic corals.

There is only one beautifully preserved specimen, which has been rolled like a pebble. That the large exposed calicles are not those of the original surface may be gathered from the traces of tabulæ seen in them. In this display of tabulæ by wearing down of the surface, cf. *G. Paris Basin 10*, Pl. X^a. figs. 1 and 2. For large calicles see *G. Dax 2*; but in that coral there is a crowding of the septa near the wall which is not the case here, cf. Pl. IX. figs. 4 and 6.

a. Geol. Dept. R. 2203.

124. Goniopora Paris Basin $_{(14)}$**1**.

[Cuise-La-Motte, Compiègne, Oise (Lower Eocene).]

Litharœa gravesi, Milne-Edwards and Haime, Polyp. Foss. des Terrains Pal. (1851), p. 143.
Astræa crispa, Michelin, Icones (1840–47), p. 162, pl. xliv. figs. 7 *a*, *b*.

Description.—Corallum hemispherical, free (with flattened epitheca).

Calicles polygonal, 3–4 mm., and slightly funnel-shaped; walls somewhat prominent, with thin, rather straight edges; septa in three complete cycles, extremely thin, "armed with conspicuous conical points." The two first cycles equal in length; the tertiaries fuse with the secondaries half-way along their courses. The columellar tangle moderately developed.

This was evidently one of the typical Paris Basin *Gonicporæ*, belonging to the group * in which the septa are beset with lateral synapticular projections, sometimes indeed showing a high degree of development, *G. Paris Basin 5*, *6* and *7*. Michelin's figure shows very slight indications of these synapticular points, hardly justifying the expression "très saillants."

The walls were thin and sharp like those of the next coral, and the growth-form was primitive. Michelin says that he only knew of two specimens, one in his own collection and

* On the morphological grouping of the Paris Basin forms, see the Remarks p. 145.

the other in that of the Abbé Lévêque at Vaugirard. An unattached corallum, a flattened epitheca, and the closing up of interseptal loculi by synapticulæ are all indications of a sandy or muddy substratum, see p. 75.

125. Goniopora Paris Basin (14)2. (Pl. IX. fig. 7; Pl. X. fig. 1.)

[Parnes and Valmondois, encrusting *Campanile giganteum* (Middle Eocene, Calcaire Grossier); British Museum.]

Astræa bellula, Michelin, Icones (1844), p. 158, pl. xliv. fig. 2.

Description.—Corallum very thin, encrusting, following the irregularities of the surface, with sharp edges sloping very gradually down to the substratum.

Calicles from 2 to 2·5 mm. across, polygonal, regular near the centre, but irregular, being drawn out lengthways, round the growing edges. The walls thin, sharp, very pronounced though not very high, the depression being a smooth shallow convex. The wall-thread is irregular, here and there thickened, but never regularly beaded like the septa. To the naked eye there appear to be about 15 to 16 rough, wedge-shaped, very perforate septa, very thick near the walls but tapering away towards the centre. The roughness is due to their edges being moniliform and consisting of close rows of small beads. Many of the thicker septa are really double near the walls, the rows of beads forking. No approach to the typical septal formula can be made out, however, owing partly to the distortion of the calicles. The septa are always straight, and when they fuse do so at sharp angles.

The septa meet irregularly to form a tangle, sometimes large, sometimes small, and the rows of bead-like granules along the edges of the septa run on to this tangle, so that it appears finely papillate.

Of this beautiful *Goniopora* there are fortunately in the Museum Collection two small encrusting patches upon a specimen of *Campanile giganteum* (Pl. IX. fig. 7). The beads along the edges of the septa appear closely set and rounded, under the lens they are rougher and somewhat angular. Round the edges and even elsewhere the calicles are quite excentric, those at the very margin sending out long septa upon the epithecal film.

The coral described by Milne-Edwards and Haime as *Litharæa bellula* can hardly have been the same as this (see next heading). Milne-Edwards' coral was said to have been convex, while this coral is but very slightly so. The walls of this coral are not what I should call "peu marquées," nor should I describe the septal formula as "deux cycles complets, et des cloisons tertiaires dans deux des systèmes," with septa "un peu épaisses"; nor is there any indication on the Museum specimens, nor in Michelin's figure, of the innermost of the septal beads being larger than the rest and simulating pali. Further, Milne-Edwards says nothing in 'Les Coralliaires' of the moniliform septa, nor of the coral being attached to the shell of *Campanile*. The septa of his coral were "légèrement flexueuses et faiblement granulées."

The two specimens are close to one another, and one has large calicles. In both the edges of the septa are beaded. Such beading may be a post-mortem (corrosion) modification of sharper, crisper points, but in this case the vertical section shows that the trabeculæ were short and thick, and that the beads are their unaltered tips.

126. Goniopora Paris Basin $_{(14)}$3.

[Auvers (Upper Eocene).]

Litharæa bellula, M.-E. & H. (non "*Astræa bellula*," Michelin), Monograph des Poritides, Ann. d. Sci. Nat. (3°) xvi. (1851).

Description.—Corallum convex, sometimes subgibbous.

Calicles nearly uniform in size, 1·5 mm., rarely 2 mm., 0·5 mm. deep. Walls not pronounced and regularly polygonal. Septa 16, nearly uniform, viz. two cycles with four tertiaries, slightly thickened, wavy and with denticulate edges. The innermost denticles are large and simulate small pali. The columella is papillate, and only slightly developed.

I record this coral here although it hardly comes in this place. It is probable that its specialisation was that of the next group (see p. 145 for the grouping of the Paris Basin forms). The slightly wavy septa with denticulate edges show fairly clearly that it was not one of those we are now describing, in which the septa are thickened by synapticular proliferations. There is no trace of waviness of septa in Michelin's figure (Icones (1844), pl. xliv. fig. 2). Further, there is some suspicion attaching to the locality; it is possible that the actual specimen described was found at Auvers, and the other localities, "Parnes and Valmondois," were added owing to the identification with Michelin's coral. It is a pity that Michelin's figured specimen was not alone described. The confusion is solely due to the habit of grouping into species, and then giving a composite description, which is too often the description of nothing in nature.

127. Goniopora Paris Basin $_{(14)}$4. (Pl. X. figs. 2, 3, 4.)

['Grignon, Montmirail, Parnes, etc.' (Middle Eocene); British Museum.]

Astræa ameliana, Michelin, Icones (1844) 157, pl. xliv. fig. 3.
Litharæa ameliana Milne-Edwards, Ann. des Sci. Nat. (3°) xvi. (1851) p. 37.

Description.—Corallum a small, swollen, subcylindrical or fusiform mass with a hole down the axis, showing that it encrusted perishable stems; the hole is lined by epitheca.

Calicles 3 mm. in diameter, polygonal, of very varying depths, some flush with the surface, others funnel-shaped. The walls are sharp and thin, crisp, and with wall-thread very irregularly wavy, with slight indications of the formation of a wall-reticulum of small rounded meshes. The 24 septa are straight, and arranged according to the typical formula, but the tertiaries are long, and fuse with the secondaries near the columellar tangle. The sides and edges of the septa, as a rule, are beset by small beads and processes, although here and there nearly smooth septa may be seen. The columellar tangle is large and flaky; it comes to the surface in the centre of the calicle, but dips down beneath the edges of the septa almost immediately. Tabulæ seem to be early formed, so that the living polyps were not deeply rooted in the skeleton.

There are three typical specimens of this coral in the National Collection from the middle Eocene of the Paris Basin. Two of them (*a* and *b*) have holes through them, of irregular

bore, oval, and from 3 to 4 mm. long-diameter, while the third specimen (*c*) did not completely surround the object which it encrusted.

Michelin named the coral *Astræa amcliana*, because Defrance * described two specimens under this name, one of which, from some unknown locality, might have been a spherical form of this coral (showing no trace of attachment), while the other, "found at Grignon," was apparently quite typical. The latter differed from the former in being slightly "spongy." Defrance speaks of this latter as occurring also at Hauteville and Orglandes (La Manche), and as being found attached to *Cerithium cornucopia* (= *Campanile giganteum*). See above, *G. Paris Basin 2*.

In the same year (1826) Goldfuss † described and figured a specimen as *Astræa muricata*, which seems to represent this coral, but he says nothing about any hole through it. He speaks of it as being found beautifully preserved in the chalk at Meudon. Michelin emphatically denied that his coral occurs there. We have at first sight no means of deciding whether Goldfuss was mistaken as to the locality, or whether there is another of these remarkable forms actually found in the chalk at Meudon. For the present, however, we are justified in assuming that this kind of *Goniopora*, which is peculiar to the Paris Basin, could hardly have been developed in Cretaceous times, and that therefore Goldfuss was in some way misled.

The incipient proliferation of synapticular points at the sides of the septa, already noted in *G. Paris Basin 2*, is here rather more freely developed. We shall find it carried still further in the next form to be described, in which it reaches an extreme.

The specimens fall easily into three stages, *c*, *a*, *b*, in the production of this unique specialisation, on the probable cause of which see under the next form, and the Remarks to the French fossils, p. 145.

Specimens *a*–*c* were presented by Professor Milne-Edwards to the Museum of Practical Geology, and afterwards transferred to the British Museum Collection.

Geol. Dept. R. 4817.

128. **Goniopora Paris Basin** (14)**5**. (Pl. X. fig. 5; Pl. XIV. fig. 9.)

[Probably Chaussy and Middle Eocene; British Museum.]

Description.—Corallum forms small convex masses, being built up by rapid continuous growth, with a few edges; extremely light and friable.

Calicles from 3–3·75 mm. across; shallow concave. Walls of varying thickness, here and there sharp thin ridges; but often broad as light flaky foams. The septa are 24 and show signs of the typical formula; but this is obscured by the proliferation of synapticular points into jagged flakes running out in all directions, not only horizontally (cf. next form). The columellar tangle is very large, and at the surface consists of an elegant open angular reticulum of delicate filaments.

The light, spongy, vertical section of this beautiful coral suggests very rapid growth in thickness. The flakes of the reticulum are not by any means all horizontal, and the meshes are slightly drawn out vertically. Both the extreme lightness of the specimen and also the

* Dict. des Sci. Naturelles, xlii. (1826) p. 384.

† Petr. Germ., i. (1826) p. 71, pl. xxiv. fig. 3.

proliferation of the synapticulæ may well have been adaptations to life on a soft foundation, such as sand. Compare the attachment of other representatives of the genus in the Paris Basin area to perishable stems and to small stones; see also the Bracklesham Bay forms. The porous skeleton of *Goniopora* reaches in the beautiful filigree of this coral an extreme point in its departure from the usual solid walls and septa of the majority of the Madreporaria.

The specimen was labelled *Litharæa* (*Astræa*) *Parisiensis* M.-E. and H., but that name referred to a true imperforate coral.

This coral seems structurally to lead on to the next form.

a. Geol. Dept. R. 4818.

129. Goniopora Paris Basin (14)6. (Pl. X. fig. 6; Pl. XIV. fig. 10.)

[Chaussy (Middle Eocene); British Museum.]

Description.—Massive, very convex, as if it had been almost globular; apparently built up of convex layers, 2–3 mm. thick. Extremely light and friable, the sections being almost like foam. The skeletal elements are delicate pearly flakes, mostly arranged horizontally, running into thin threads.

The calicles large, 3·5 mm. across, almost invisible, at least in transverse sections. The walls, septa, and columella melted together into a tangle of flakes and threads. The columellar tangle is composed mainly of flakes and not of filaments as in the last coral. The calicles are only discoverable in the section where a few interseptal loculi betray their presence by their radial arrangement. The septa, those few which can be recognised as such, are very twisted, mostly horizontal irregular flakes.

There are two nodules of this coral, the larger, 5 cm. long, showing the method of growth and the extraordinarily spongy texture of the skeleton. The original surface may have been worn down and it is possible we have only a section. But for the clue supplied us by the preceding coral these would have remained enigmatical. They now, however, find their place in the series, showing the gradual specialisation of the synapticulæ. They appear to differ from the coral just described in the fact that the flakes are horizontal, and that the columellar tangle consists wholly of them. This flaky character may be associated with the formation of thinner colonies.

A case nearly parallel to this will be described in the next volume, as occurring in the genus *Porites*, viz. a thin explanate form consisting entirely of horizontal flakes. Cf. *G. China Sea 3*, p. 72.

a. Showing 2 calicles, as figured on Pl. X. fig. 6. ?

b. Shows no radial structure. Geol. Dept. R. 1991.

130. Goniopora Paris Basin (14)7. (Pl. X. fig. 7.)

[? Locality; Eocene; British Museum.]

Description.—Corallum smooth, very convex, as if forming half a cylinder, but complete form unknown.

Calicles large, nearly 4 mm., concave. Walls thick, and forming somewhat blunt ridges. The angles thick, and tending to surge up with young buds appearing on them. The texture of the walls is a very close reticulum of thin threads and minute pores, without beauty of form. This close reticulum runs out along the edges of the septa, broadened by the synapticular proliferations characteristic of so many of these Paris Basin forms. It becomes transformed, however, about half-way along the edges of the septa into a system of broad flakes, which gradually sweep down into the floor of the calicle to form the columellar tangle, which is composed of large, straggling, flattened flakes with a few small perforations. The septal formula appears to be typical, but confused by the extraordinary breadth of the individual septa.

The vertical section of this coral shows the thick horizontal flakes of the columella thinning away on the lateral faces of the septa, which are not very perforate, but are covered with small flattened projections, the synapticulæ.

This coral is much denser than either of the two foregoing, and had evidently a different growth-form. A comparison of the figures of the calicles shows the differences between the three. They are all variations upon the same method of protecting the retracted polyp against sand or mud. These protections consist of the formation of (*a*) flakes and (*b*) a filamentous reticulum. In *G. Paris Basin 5* the walls are flaky and the columella filamentous; in *G. Paris Basin 6* the septa and columella are flaky, the flakes twisted about, and the walls are an open elegant reticulum, while in this coral the walls are closely reticular, and the columellar tangle is composed of horizontal flakes, the synapticulæ changing from filaments to flakes.

I am inclined to think that while the two former built up light masses, this coral was tougher and thinner, and possibly encrusting.

a. Geo. Dept. R. 4219.

131. Goniopora Paris Basin (14)8. (Pl. X. fig. 8.)

[Parnes; Middle Eocene; British Museum.]

Description.—Corallum thin, encrusting, 4·5 mm. thick; surface almost flat, or only slightly convex; thick, white, wrinkled epitheca.

Calicles 3–3·5 mm. across, sub-polygonal, shallow concave depressions. Walls uniform, blunt ridges about 0·5 mm. thick. The septa uniformly thickened by a dense, finely granular proliferation of the synapticulæ, which runs up to the wall-ridge here and there, changing it into a close reticulum with minute pores. Towards the centre of the calicle the synapticular proliferations change into flakes, which form the columellar tangle. The surface of this is finely roughened, and is perforated by a few minute pores.

The vertical section shows an exquisitely delicate, nearly uniform reticulum, in which, however, the closely arranged horizontal wavy flakes are the chief constituents, there being no very distinct vertical trabecular elements.

This coral is evidently closely allied to the last. There are three specimens, a portion of a thin encrusting stock, and two minute young colonies, differing from the stock in that the

wall-ridges are very sharp. It is impossible to say for certain into what these young colonies would have developed. The synapticular proliferation on their septa is exactly like that above described; the flaky columellar tangle is absent in the smaller colony, but begins to appear in the larger.

These are the last of the specimens showing the curious synapticular proliferation of the septa. The next forms are, however, nearly as remarkable, but do not admit of being arranged into series, as the essential character of the specialisation is not so easily perceived.

a.–c. Geo. Dept. R. 4820.

132. **Goniopora Paris Basin** $_{(14)}$**9.** (Pl. X. fig. 9; Pl. XIV. fig. 11.)

[? Exact locality; Eocene; British Museum.]

? *Litharæa Heberti*, M.-E. & H., Nat. Hist. Coralliaires, iii. (1860) p. 187.

Description.—Corallum lens-shaped, with smooth surface. The successive edges not bending far under the circumference of the stock.

Calicles only faintly distinguishable in the loose, open reticular skeleton, about 3 mm. in diameter. Slightly and irregularly depressed. The walls rise so irregularly that they nowhere form continuous ridges and are thus very inconspicuous. Closely examined the wall-thread is seen to be thin, but slightly thicker than the septa, and to form only fragments of a wavy rather than zigzag boundary to the calicles, the waves or angles being so large and the thread so interrupted that the wall seems to have dissolved into the loose open-meshed reticulum. The septa are very wavy, not of uniform thickness, and are joined irregularly by thin synapticulæ; the number and arrangement of the septa is quite irregular and obscure. A few large, open, interseptal loculi are generally present; the large gaps in the wall enable them to run into those of adjacent calicles. The columellar tangle is variously developed, the tapering edges of the septa forming sometimes an open large-meshed reticulum, not sharply defined from the rest of the intracalicular skeleton.

The surface aspect suggests that the skeletal elements are all lamellate, but in the section hardly any lamellæ can be seen, but thin wavy vertical trabeculæ separated by large oval pores, so that the stock is very light but not friable, for the elements are all fairly thick.

This specimen was tentatively labelled *Litharæa Heberti* M.-Ed. and H. Its walls are certainly not distinct, but it can hardly be said that the calicles are polygonal, for their boundaries seem to have dissolved away, and further, none of the really important features in this coral are noted in Milne-Edwards' description. For an extreme development of this type of structure cf. *G. Coutances 2*, p. 144.

a. Geol. Dept. R. 4821.

133. **Goniopora Paris Basin** $_{(14)}$**10.** (Pl. X^a. figs. 1 and 2.)

[Auvers (Upper Eocene); British Museum.]

Description.—Corallum massive, in large blocks, original shape of which is unknown.

Calicles, 2 mm., rather deeply concave, subcircular, with very thin, sharp wall-thread

running in a pronounced wavy or zigzag pattern. Some 20 septa spring from the walls, quite short at the margin but gradually lengthening below. They are very wavy and angularly bent, nearly all smooth but of varying thicknesses. Their arrangement is obscure, for they soon join a ring of synapticulæ which seems to mark the boundary of a loose columellar tangle. Between the wall and this tangle there is frequently a ring of open, interseptal loculi, many of them nearly circular. The columellar tangle shows no special closeness of its reticulum, but has large rounded meshes like the interseptal loculi. Immense numbers of tabulæ are developed, and the fossæ appear to have been shallow, i. e. tabulæ began to appear very early among the meshes of the columellar tangle. In fig. 2 these show at the surface more conspicuously than in fig. 1.

There are two specimens; the larger, without definite locality, came originally from Professor Milne-Edwards with a label upon it "*Porites Deshayesiana*, Michelin." Milne-Edwards* wished to identify Michelin's coral with a *Litharæa*. But if Michelin's figure † is correct in its main details it was a true *Porites*, while the coral above described is a true *Goniopora*. Milne-Edwards' description seems to have referred entirely to Michelin's figure, but why did he call it *Litharæa*? Perhaps he had this or some kindred specimen in mind which he incorrectly identified with Michelin's coral. Once more we have to note that the confusion is due to the attempts to group into species, which these great naturalists were compelled to make by the prevailing system.

The specimen is large, and from the number of boring molluscs is probably a fragment of a very massive stock. The surface is all worn down so that the calicles look flush with the surface; but the number of portions of tabulæ which show at the surface are evidence that we are looking at sections. In one place only, where an original surface was apparently grown over by a fresh layer and uncovered again by a fracture, do we see what may have been the original walls, and it is from this small part that I have, though with some hesitation, given the details in the description. The illustration is from the worn surface.

The smaller specimen, said to be from Auvers, and with smaller calicles, seems to have been part of a worn pebble: it shows essentially the same characters, only the intersepta loculi and the meshes of the columellar tangle are smaller. The traces of boring molluscs are visible, suggesting that this specimen also originated from a large massive stock. The tabulæ are the most conspicuous skeletal element of the worn surface.

The larger specimen was transferred from the Museum of Practical Geology in 1880.

Forms of similar horizon and very closely allied to this are found in La Manche, see *G. Coutances 1*, but the growth-form is very different. Those which now follow and still belonging to the Paris Basin are also allied, in that they all have the lamellate septa with smooth top edges; but each has an aspect of its own.

a, *b*. Geol. Dept. R. 4822 and R. 4823.

134. Goniopora Paris Basin $_{(14)}$11. (Pl. X^a. fig. 3; Pl. XIV. fig. 12.)

[Auvers (Upper Eocene); British Museum.]

Description.—Corallum forms irregular convex masses tending to overhang the base of attachment. The surface is quite smooth.

* See Hist. Nat. Coralliaires, iii. (1860) p. 187. † Icones, 164, pl. xlv. fig. 4.

The calicles are frequently flush with the surface, very small, ranging from 1·5–2 mm., polygonal to the naked eye. The wall when thin is very inconspicuous, there being no continuous wall-thread traceable round the calicles, usually irregular skeletal tissue separates calicle from calicle, either thin with very few pores, or thick and with many pores like a reticulum, and it is then raised slightly as a low ridge. The pores in the top of the wall are specially minute. The septa, about 20 in number, are not quite radially symmetrical. When the wall is thick and reticular they are very thick near the wall and taper inwards, often irregularly moniliform. The directives are long and sometimes form a continuous keel across the calicle; on each side of this, symmetrical portions of the typical formula may sometimes be seen. Many of the septa seem to start forking just as they reach the wall. While their top edges are smooth and rounded, their sides are roughened by very thin incipient synapticulæ. The interseptal loculi are narrow and slit-like. The columellar tangle varies in size, the thickened tips of the septa either fusing or joined by exquisitely delicate synapticulæ, in strong contrast with the thick septa which they unite. When the wall is slightly raised, the pali formation is typical, slightly raised thickenings appearing on the columella at the points of fusion of the septa.

In section, the texture is composed of nearly straight trabeculæ densely crowded together, with only small pores between them.

There are three specimens of this coral from Auvers, differing slightly from one another, and a fourth from some unknown locality in France. The specialisation appears to differ entirely from that of any *Goniopora* yet described, but in reality the septa appear to be lamellate and essentially of the same character as those of the last two forms. It is not impossible that the closeness of the skeleton, the small size of the slit-like interseptal loculi, these being still further closed by the synapticulæ, may be adaptations to meet the danger from sand here so often alluded to (see Remarks, p. 145).

This is another of the French Goniopores which might be taken at first sight to be *Porites*. We have already described *Goniopora Gironde 1* and *G. Dax 4*. All three can be distinguished from *Porites* by the forking of the septa near the walls. In none of them can we find true transition forms, because, as shown in the Introduction, the septal formula of *Porites* can be deduced from that of *Goniopora* by a reduction of the tertiaries according to a regular pattern. This regular pattern is not seen in any of these, the reduction being quite irregular and generally obscuring the typical arrangements.

Of the three specimens from Auvers, one has exclusively thick walls, while both thick and thin can be found on the other two. There is no mistaking the characters of this coral, the comparatively speaking thick, irregularly moniliform septa, and the fine synapticulæ, mostly as teeth, but, nearer the columellar tangle as definite bars, which help to form the tangle. The paliform swellings are only seen on the specimen with thick walls.

The fourth specimen is probably from the same locality. It has thin walls and is flat and encrusting. There is no mistaking the similarity in general character.

a.–c. Geol. Dept. R. 55,680.

d. „ „ R. 4824.

135. **Goniopora Paris Basin (14)12.** (Pl. X[a]. fig. 4.)

[Le Fayel,* north-west of Paris, near Marines (Upper Eocene); British Museum.]

Description.—Corallum, form unknown, a small smoothly worn fragment of what appears to have been a massive block.

Calicles 2 mm. in diameter, not very conspicuous in the section. The wall a thin but stout reticulum, the pores on the tops of the walls not so minute as in the preceding coral. The septa angularly bent and twisted, here and there stout, but nowhere of uniform thickness, at one point swollen into a knob and then thinned down to a thread. The columellar tangle consists of the same kind of elements. The interseptal loculi and other meshes are all fairly open, but the radial symmetry of the former is not very marked.

This coral is clearly connected with the preceding, but the extraordinary contrasts which characterised that coral between the swollen walls and thick moniliform septa on the one hand, and the minute pores and the delicate synapticulæ on the other, are not seen here. This, therefore, is not quite so specialised as the foregoing.

The fragment appears to be part of a small flat pebble, 1 by 1·5 by 0·5 cm.

136. **Goniopora Paris Basin (14)13.** (Pl. X[a]. fig. 7; and Pl. XIV. fig. 13.)

[Auvers (Upper Eocene); British Museum.]

Description.—Corallum forms small rounded nodules, expanding rapidly above a small base of attachment, with straight sides and somewhat flattened top.

The calicles 2 mm. in diameter, shallow and circular. Walls round-topped, rather thick (? slightly raised), and consisting of a ragged very open reticulum, without any trace of median ridge, or wall-thread or membrane, or of septal striation, or indeed of any of the ordinary mural characters. Some 12–13 septa, separated by large open interseptal loculi, are conspicuous, but not only do many of them seem to fork near the walls, but knobs and points of the wall-reticulum also suggest that the real number is greater. The septa when complete are angularly wavy, and with occasional synapticular spikes, which meet irregularly across the loculi; further, though very perforate, they are conspicuously lamellate. The columellar tangle is an open irregular reticulum similar to that seen in the walls. There is a tendency for some of its filaments to widen out into large flakes.

There is one apparently perfect little specimen of this coral. It is not easy to say how far it has been worn. The apparent growth-form (an inverted cone) may be natural, but is

* There seem to be other Le Fayels in France, but this is probably the one mentioned on p. 49 of Messrs. Harris and Burrows' 'Paris Basin' (*Geologists' Assoc.*), 1891.

perhaps due to attrition. Similar natural growth-forms are already known, see *Goniopora Tonga Islands 3*, Pl. XI. fig. 7; and *G. Maldive Islands 3*, Pl. XIII. fig. 8.

The top of the stock is irregular, and it is difficult to say whether a sunken patch in the middle of it is natural or artificial. In this patch the calicles are slightly deepened, but the columellar tangle is somewhat raised, and it is possible that the deepening may be due solely to the breaking away of the delicate septa by the forcing in of sand-grains, which are everywhere entangled in the meshes of the reticulum.

This type of calicle, with its lamellated septa, seems to link on best with the group represented by *G. Paris Basin 9* and *10*, and with the specimens from Coutances, see next page. But the perforations in the septa are so numerous as rather to disguise their lamellate character. In the next coral, on the other hand, the lamellate character of the skeleton is carried to an extreme.

a. Geol. Dept. R. 4825.

137. **Goniopora Paris Basin** $_{(14)}$**14.** (Pl. X^a. figs. 5, 6, and 8; Pl. XIV. fig. 14.)

[? Exact locality; Eocene; British Museum.]

Description.—Corallum small, as a blunt cone apparently built up of two or three colonies, not closely encrusting, that is, of colonies which appear continuous with one part of the stock, but overarch another. In the type specimen the smallest and youngest at the top is free and arching for half its circumference, but continuous with the older growth for the other half.

The calicles are very deep in the central regions, but are flush with the surface on the downwardly sloping edges of the stock, from 2–2·5 mm. in diameter, with marked differences in the characters of the walls. In the deep calicles the wall is a straight, stout, smooth membrane, with an occasional vertical slit, but with hardly any traces of pores, while in the shallow calicles it is a coarse, very irregular, open-meshed reticulum, with hardly any traces of wall-thread except where the two kinds of calicle are passing into one another. The threads of the wall-reticulum are stout, smooth, and obviously form the top edges of vertical membranes, bent and twisted, and fusing together. The septa are very irregular and difficult to count, thick and forking near the walls, on which there are usually some 20 points of attachment. They are conspicuously lamellate and fairly radially arranged, but slightly wavy with jagged sides and granulated top edges; the lateral points frequently fuse and form a reticulum of threads of varying thickness. The whole reticulum is more delicate the nearer it approaches the edge of the colony. In the deep calicles the septa seldom start from the top edges of the walls, and the knobs or smooth granules along their upper edges are crowded together so that the base of the fossa is a mere irregular mass of minute papillæ, which, however, show no traces of symmetrical pali.

The beautiful little coral above described, with its skeleton built up of smooth vertical lamellæ, has the pores of its walls almost obliterated, and, like the last, links on to *G. Paris*

Basin 9 and *10*, or on to *G. Coutances 1* and *2*. But, as may be seen in the figures, it carries the lamellate character of the skeleton, obscured in the last, to an extreme. There is no other resemblance between it and the other Paris Basin forms. It is quite peculiar in the almost sudden transition between the shallow calicles with reticular walls and the deep calicles with smooth walls. In sections at the edges where, as stated, the skeletal elements are thinner, the pores through the walls can be easily seen. This shows that their obliteration is secondary. On Pl. XIV. fig. 14, showing the growth-form, one can see a small free edge starting on the very tip of the stock in a manner suggesting unfavourable conditions; for such a free edge might be formed, for instance, to creep over sand which had perhaps risen higher than usual around, and threatened to bury the stock.

There is a second specimen with a coarse outer surface and broken sides, the whole being something like a small segment of a regular hemisphere. It differs from the first specimen in having fewer calicles showing the tall membranous walls—only the beginnings of such walls can be seen. The septa show the same general characters, and it is clear that this is only another growth of the same coral, and perhaps part of a more normal colony. Its label only stated Middle Eocene, Paris, but it is structurally closely allied with the specimen above described.

a. A small conical colony, Pl. XIV. fig. 14, and Pl. X^a. figs. 5 and 6. Geol. Dept. R. 4826.
b. A fragment, like a thin segment of a hemispherical stock, Pl. X . fig. 8 (× 5 times).

138. **Goniopora Coutances** $_{(2)}$**1.** (Pl. X^b. fig. 1; Pl. XIV. fig. 16.)

[Hauteville, Coutances, La Manche (Middle Eocene); British Museum.]

? Litharœa desnoyersi, M.-E. & H., Hist. Nat. Coralliaires, iii. (1860) p. 188.

Description.—Corallum forms irregularly nodulated finger-shaped masses, 5 to 6 cm. long, and varying in thickness from 1·5 to 2·5 cm. These small thick columns seem to have grown on the tips of organisms which have decayed, for in each of the two specimens there is at one end an irregular epitheca-lined indentation running a few mm. into the coral in two or three directions, as if the tip of the organism had been forked.

The calicles are large, 4 mm., polygonal, deep. Walls thin, membranous, sharp edged, and, seen laterally, jagged (unless corroded when they may be thick and smooth). The 18–20 septa are thin and membranous and project sharply right from the top edges of the walls; they slope with a concave curve into the base of the calicle, and as they descend their edges may run out into long irregularly curved spines. In the base of the calicle these spines run together to form a remarkable open reticulum, with large meshes between a few boldly curling slightly flattened strands.

This coral again is quite peculiar; it is probably the same as that described by Milne-Edwards as *Litharœa desnoyersi*, from this locality. It might easily suggest a fragment of a thick "subdendroid growth," but there is every reason to believe that the stocks we have in

the Museum are practically complete except where the wall-edges have been altered by aqueous action, or rubbed down by rolling. The rest of Milne-Edwards' description agrees fairly well. It is not correct that the innermost septal spines are always the longest, sometimes those near the calicle aperture project furthest; nor is the columellar tangle papillose, but a smooth thick coil as described.

This is one of the *Gonioporæ* whose texture is essentially lamellate, reminding one of a group of Paris Basin forms, of which *G. Paris Basin 14* is specially remarkable. It may be noticed, however, that the Paris Basin forms which were attached to other (? vegetable) organisms showed an entirely different calicular structure (see *G. Paris Basin 4*).

There are two specimens, one identified by Martin Duncan as *Litharæa desnoyersi*, and the other transferred from the Museum of Practical Geology in 1880.

a, b. Geol. Dept. R. 2012 and R. 4827.

139. **Goniopora Coutances** (2)**2.** (Pl. X^b. fig. 2.)

[Hauteville, Coutances, La Manche (Middle Eocene); British Museum.]

Description.—Corallum encrusting, convex, with its thin lateral edges tending to envelop loose objects growing under them.

Calicles 3 mm. across, about 2 mm. deep in the highest central parts. The walls show very irregular wall-threads or membranes, zigzag, and bent and twisted so as frequently, with the forking and bending of the septa, to form an open-meshed flaky reticulum. The membrane is very porous, with openings quite irregular in shape and position. The septa, which do not project far into the calicle, are also perforate membranes; they are very irregularly twisted about, with spiny edges which are bent from side to side, obscuring the radial symmetry and forming together an incomplete, very jagged, flaky reticulum on the inner sides of the walls. The columellar tangle is an open large-meshed coil of thin filaments and flakes.

A glance at the figure will show the extraordinary skeletal structure of this coral. It clearly belongs to the Paris Basin group characterised by the smooth lamellate texture of the skeleton (compare, for example, *G. Paris Basin 9, 10* and *14*). But here the waviness of the walls and septa have reached an extreme.

The clearing away of a portion of the sand grains entangled in this complicated membranous reticulum, which was a necessary preliminary to examination, was very difficult without accidentally detaching portions of the skeleton. Hence the figure does not represent the exact original surface. But there is no reason to believe that that differed very greatly from what we can see.

a. Geol. Dept. R. 4828.

140. **Goniopora France** *a.** (Pl. X^b. fig. 3.)

[? Paris Basin; ? Middle Eocene; British Museum.]

Description.—Corallum massive.

Calicles very minute (1 mm.) and inconspicuous. The wall-thread irregularly swollen,

* On this designation see the prefatory note to Group XIII. p. 154.

very straggling, seldom continuous round a calicle, merely indicating the irregular polygonal boundaries between the calicles. The septa, 13–14, forking in twos and threes near the wall, are very irregular, and bent in all directions so that the radial symmetry is greatly obscured. The curling septa meet irregularly in the centre, forming a large, ill-defined columellar tangle.

The vertical section is built up of straight nodulated trabeculæ, rather stout, but separated by rows of pores of about equal diameter with the trabeculæ. Immense numbers of tabulæ are developed.

This remarkable specimen, without recorded locality, has the habit of a *Porites*, but is placed in this genus for the following reasons:—*a*. There are, generally, one or two more septa than in *Porites*, i. e. 13–14 instead of 12; *b*. The septa fork near the walls, which suggests a reduction of the typical formula of *Goniopora* (see Introduction, p. 21), and there is no resemblance whatever to the septal formula of *Porites*; *c*. There seem to be indications of a columellar tangle, which is not common in *Porites*. Any one of these reasons would have been sufficient, but the three together leave no doubt in my mind as to the correctness of placing the coral here.

The specimen is remarkable because it is one of the two *Gonioporæ* with the smallest calicles yet described (see p. 183). It is unfortunate that its locality is unrecorded.

Comparing it with other known French *Gonioporæ*, it may either link on with such forms as *G. Gironde 1* or *G. Dax 4*, which latter also has very minute calicles, or with *G. Paris Basin 11* and *12*. The boring molluscs, apparently of the genus *Thylacodes*, secreting calcareous tubes with conspicuous hemispherical diaphragms, which burrowed through it, are known both in the Eocene of the Paris Basin and in the Aquitanian beds of the districts near Dax. Our suggested locality and horizon for this coral are purely provisional.

a. Geol. Dept. R. 957.

Remarks on the French Forms.

The figures and descriptions show clearly that the *Gonioporæ* of the Paris Basin were, with few exceptions, very highly specialised. The primitive type of calicle described in the Introduction, with its tendency towards fluency as opposed to the rigid symmetry of the great bulk of the Madreporarian corals, reached an extreme in this direction in these remarkable fossils. I know of no Madreporarian showing such developments of flaky and filamentous networks as those shown, for instance, in Pl. X. fig. 5 and in Pl. X^b. fig. 2.

The great majority of them were evidently small colonies, and their larvæ seem to have been compelled to find precarious footholds on a sandy bottom. Many seem to have been attached to weeds, which is still a common occurrence with recent small-calicled forms (e. g. *Porites*); others to shells and small pebbles. This was also the case with their congeners whose remains are now found in the Bracklesham Bay of Sussex.

The number of small forms alone, in a genus which consists typically of reef corals and produces large colonies, is enough to suggest an unfavourable environment. Knowing as we do, from the beds in which they are found, that they mostly grew on sand or mud, we need not postulate any disadvantageous climatic conditions; for these two forms of the sea-bottom are, of all others, the most inimical to coral growth.

Only small stocks could develop on a substratum which supplied no solid foothold, and only corals whose skeletons were adapted to enable the individual polyps to cope with deposits of sand-grains could survive. It is for this latter purpose I would suggest that the extraordinary proliferation of the intra-calicular skeletons of so many of the Paris Basin specimens may be due. A close network would form a better support to the delicate walls in the event of sand settling on the calicles than a series of straight radial septa, between which the sand-grains might sink.

The specialisations seem to have travelled along three lines:—(1) They may form proliferations of the synapticular outgrowths, shown in the group illustrated on Pl. X. figs. 1–8. (2) They may have smooth membranous walls and septa, very wavy and twisted so as to form a flaky reticulum (see Pl. X. fig. 9, Pl. X^a. figs. 1, 2, 5–8, and X^b. figs. 1 and 2). These forms frequently show also a great development of tabulæ (see Pl. XA. figs. 1 and 2); and (3) they may show a striking diminution in the size of the calicles, departing from the typical septal formula of *Goniopora*, and taking on the appearance of a *Porites*. The skeleton is then a very close and compact reticulum, and the interspaces necessarily very minute (Pl. X^a. figs. 3 and 4).

I would not assert that it is possible to divide the specimens into true genetic groups along these lines, but only that there is a very marked tendency of the Paris Basin forms to be specialised in one or other of these directions.

The first of these groups has some historical interest. It contains several forms with shallow gaping calicles and large spongy columellar tangles, the latter showing *no traces of pali* (see Pl. X. fig. 5). This is also the case with specimens of *G. Sussex 1*, which, as *Litharæa Websteri*, was the type of the genus *Litharæa* (see Pl. X^b. fig. 7). Absence of pali was naturally given as one of the characters distinguishing this genus from *Goniopora* and from *Rhodaræa*; indeed the three genera, it was thought, formed a series:—*Litharæa* without pali, *Goniopora* with pali in the "young" calicles but disappearing in the "adult," and *Rhodaræa* with pali always forming a conspicuous rosette. As between the last of these two we have sufficiently discussed this supposed generic distinction in the Introduction to this Volume, and have pointed out at the same time that Milne-Edwards' "young" and "adult" calicles do not admit of being so distinguished. A few words will suffice to show that no generic distinction can be established between *Litharæa* and *Goniopora* upon the presence or absence of pali. For not only have several *Litharææ* been described with developed pali (e.g. *G. Vicenza 3, 5, 8*, see also distinct traces of pali in Pl. X. fig. 2), but a tendency to the obscuration of the pali is quite observable in recent forms whenever the calicles are gaping and shallow, with large reticular columellar tangles (see, for instance, Pl. IV. fig. 9 and Pl. VIII. fig. 6).

As compared with the fossil *Gonioporæ* from Italy and Austro-Hungary, even though D'Achiardi spoke of one of the former as if it had just come fresh from the sea, and Reuss figures much fine detail, the French representatives of the genus are more uniformly well preserved. The finest details of structure are nearly always recognisable. Add to this the facts (1) that the Paris Basin forms appear to have been an isolated group, and (2) that they show specialisations of structure not elsewhere met with in any other part of the world, and we have ideal conditions for the careful local study of the genus in relation to the different horizons at which specimens occur. The Paris Basin groups seem to range from Lower to Upper Eocene; I would suggest that a study of all the available *Goniopora* material now stored in French museums, added to by fresh finds when the localities are revisited, would

probably show structures varying in ordered sequence from stratum to stratum. It is even possible that in some cases the causes and the nature of the variations might be definitely correlated with some of the recognisable changes which must have taken place in the environments. I can do no more here than call attention to such an undertaking as one of the great desiderata in the study of animal life.

Group X.—ENGLAND.

Containing descriptions of Fossil Goniporæ from Bracklesham Bay in Sussex (Middle Eocene), and from Brockenhurst in Hampshire (Oligocene, Headon Beds).

These fossils are allied to those of the Paris Basin. The nearest French locality is Coutances, in La Manche. Besides the delicacy of skeleton and the elegance of the intracalicular pattern which these corals had in common with their French congeners, we may note that they had somewhat the same unfavourable environment. Both the Coutances fossils seem to have been attached to organisms, probably vegetable, indicating thereby that they had no solid rock to rest upon. The same is true also of the majority of the Paris Basin forms. And here in Bracklesham Bay the stocks are always attached precariously to what I judge to have been sparsely scattered pebbles of different sizes and of varying stability.

141. Goniopora Sussexiana. (Pl. X^b. figs. 4–7.)

[Bracklesham Bay, Sussex (Middle Eocene); British Museum.]

Astræa websteri, Bowerbank, Mag. Nat. Hist. (Charlesworth), iv. (1840) p. 24, figs. A and B.*
Litharæa websteri, M.-E. & H., Brit. Foss. Corals (*Mon. Pal. Soc.*) (1850), p. 38, pl. vii. figs. 1 and 1 *b*.†
Siderastræa websteri, Lonsdale in Dixon's Sussex (1850), p. 138, pl. i. fig. 5 *a–c*.‡
Litharæa websteri, Duncan, British Fossil Corals (*Mon. Pal. Soc.*) (1866), pl. iii. fig. 4.§

This name applies to a group of corals which seem to be very closely allied genetically. They show, however, so many variations that no single detailed description could possibly cover them. The only points which they seem to have in common are contained in the following description.

* The figure of the magnified calicle appears to represent a specimen with calicles somewhat like those figured in Pl. X^b. fig. 7, but without columellar tangle. See remarks on specimen No. 30 in this Catalogue, p. 152.

† These figures are good, but the wall is wrongly represented in the vertical section.

‡ These figures appear to be of specimens Nos. 1, 2, 23 and 29 in this Catalogue (= figs. 5*a*, 5*e*, 5*b*, *c*, *d*, and 5, respectively). The morphology of the skeleton was not understood, hence they are not very accurate.

§ This figure seems to be a copy of part of one of those above referred to from Milne-Edwards, but is even more incorrect. The septa are all drawn free, and sloping with a convex curve evenly into the fossa.

Description.—The corallum encrusted flint-pebbles, or shells. If the pebbles were large, it formed thick convex cakes, as much as 12 cm. long by 9 cm. or more across. Sometimes it bound several pebbles together; if the pebbles were small and isolated so that the colony could not spread laterally, it thickened and formed globular, oval, or dome-shaped stocks, from 2 to 6 cm. in diameter.

The calicles are usually but slightly depressed, the skeleton is thin and delicate, the septa are perforated and arranged according to the typical formula, with sometimes a few of the fourth cycle represented; they never end freely. The tertiaries fuse with the secondaries, and the primaries and secondaries with the columellar tangle, which is always present, sometimes very large, at others only just traceable.

These are merely the generic characters modified by the accident of having to grow on pebbles.

There are 32 specimens grouped under this specific name in the British Museum, and the variations can best be described in connection with the different specimens. All of them are from Bracklesham Bay.

Specimen No. 1. A large pebble, with six young colonies of different sizes, with wide flattened, epithecal films surrounding them; from these films the rudiments of the skeleton can be seen rising. In the smallest or youngest colonies, in which the calicles are also very small, it appears as if multiplication by fission took place; in the adult gemmation from the reticular wall-angles is the rule, though even here also traces of what looks like fission can be seen. I have found it in no other *Goniopora*.

The largest calicles are 3·5 mm. and 1 mm. deep; in the central regions of the colony they are funnel-shaped, with sharp, thin, ridge-like walls, with an irregular wavy or zigzag wall-thread; when sharpest and highest, the thread is straight. The primaries and secondaries start from the ridge, and are thus often conspicuous. The septa are finely serrated, with frosted or finely echinulate sides. The three cycles are often of different thicknesses. The columellar tangle is not conspicuous.

This is the specimen referred to and figured by Lonsdale in Dixon's 'Sussex,' 1850, p. 139, Pl. I. fig. 5 *a*. Geol. Dept. 48334.

These being the characters of the youngest colonies we are perhaps justified in assuming that they are nearest to the ground-form upon which all the other specimens are variations. I accordingly arrange the next seven specimens first in the following list (cf. also Nos. 15 and 16), because they show clear traces of having had these characters, with slight variations in sizes of calicles and thickness of septa. Of the more striking variations seen in the remaining specimens some few may be safely referred to abrasion of the surface. Abrasion, for instance, would take off the wall-ridge and show the wall as a reticulum, but it will not account for the different *kinds* of reticulum which occur. Abrasion would account too for revealing a columellar tangle, in the event of its being obscured in the calicles at the surface, but it will not account for the slight development of that tangle in some and its enormous proportions in other specimens. The chief variations met with in the specimens are:—

The septa are either very smooth and thin, or else very echinulate (cf. figs. 6 and 7).

They are very perforate, so as to be a mere lattice-work, or else almost entirely laminate.

They may either run very straight and symmetrical, or tend to be wavy and to lose the radial symmetry.

The calicles vary greatly in size.

The wall, always reticular, is thin, or thick. The reticulum may be of thin threads with open angular meshes, or else of stout flakes with quite minute pores like worm-borings. All stages in the gradual thickening of the wall-thread can be found.

The columellar tangle may be large, Pl. X^b. fig. 7, or hardly visible, fig. 4 (see Spec. No. 12).

These variations make it impossible to give a single description which would embrace all the specimens. We will therefore catalogue them separately

Specimen No. 2. Pl. X^b. fig. 4. A small rounded nodule detached from its pebble. Wall-ridges sharp, calicles nearly 4 mm. across, and the angles where the sharp walls meet appearing somewhat raised into points. This is almost certainly the specimen figured by Lonsdale, Pl. I. fig. 5*e*, which was formerly in Mr. F. E. Edwards' Collection.

Geol. Dept. 49573.

Specimen No. 3. Pl. X^b. fig. 6. Closely encrusting a Fusoid shell. The calicles on the top are 5 mm. across and deeper than usual, but at the sides they diminish to 2·5 mm. and are like those of the young colonies. The walls between the deep calicles tend to be reticular, and are round-topped instead of sharp. Geol. Dept. 49571.

Specimen No. 4. A solid dome-shaped mass attached to pebble. Calicles average 4 mm. The wall-edges are irregular in height and texture. Tending to be reticular in the angles where buds form. Geol. Dept. 30907.

Specimen No. 5. A detached flat ovoid mass apparently more rolled than the last, which it seems to greatly resemble in finer details. Geol. Dept. 49574.

Specimen No. 6. An irregular growth, apparently due to the partial falling over of a colony attached to a small base. The portion then uppermost seems to have grown out so as to overhang the original colony. The wall-ridges rise to different heights.

Geol. Dept. 48336.

Specimen No. 7. A large convex cake, which began by encrusting a pebble and gradually spread over others which happened to be near. One half has the typical funnel-shaped calicles, with sharp wall-edges; the other half has been abrased, and the walls are consequently reticular. The reticulum appears rather dense, owing probably to its flaky texture.

Geol. Dept. 48336.

Specimen No. 8. Seems also to have spread as a rather thin cake over several pebbles. The surface has been worn down smoothly, and shows the same characters as the abrased half of No. 7. The skeletal elements of creeping edges are seen to be exceptionally delicate.

Geol. Dept. 48335.

Specimen No. 9. A very large mass upon a single large pebble, in two pieces. It is difficult to say whether the surface is much abrased. The calicles about 4 mm., and the walls very irregular, here quite thin so that the septa seem to run across from calicle to calicle, and there as small patches of reticulum which, though formed of thickened skeletal matter, are yet not dense. Geol. Dept. 49575 and R. 4829.

Specimen No. 10. A large tortoise-shaped mass detached from its pebble. The surface markings are somewhat like those of No. 9, only the wall reticulum is more uniformly distributed and its meshes conspicuously open and angular. Geol. Dept. R. 4830.

Specimen No. 11. Is a pear-shaped knob, detached from its pebble. The calicles are typical in shape, but larger (5 mm.) and shallower, and the wall lower and not so sharp. The skeletal elements are very delicate. Geol. Dept. 48335.

Specimen No. 12. Seems to be a fragment of a similar pear-shaped stock, broken down the middle. The outer surface is worn. The inner shows a complete vertical section. The skeletal elements are thin, as in No. 11. The septa, seen in vertical section, are very thin and laminate, the laminæ being strengthened by rows of echinulæ or slight ridges slanting upwards towards the axis.* They are very irregularly perforated, the pores often in groups, sometimes very scattered, at others so close as to make a lattice-work. The septa, *in one and the same calicle,* vary in width and consequently the columellar tangle which involves their ragged edges varies also in size. Geol. Dept. 48335.

Specimen No. 13. A small fragment perhaps of the same, but shows the lower edge of such a colony with the calicles all dragged out of shape, and the septa running from calicle to calicle. Geol. Dept. 48335.

Specimen No. 14. A good sized fragment of a large ovoid mass, bored by *Gastrochœna.* Its core has been impregnated with iron ; the surface has been abrased. The wall-reticulum is open and the elements thin in the sections. On parts of the surface the septa and the wall-elements seem to become thicker and more flaky, but this may be the result of post-mortem aqueous action. Geol. Dept. 48337.

In the following the septa mostly thicken towards the wall, as described by Milne-Edwards and Haime; the threads of the wall itself are irregularly thickened or nodulated, and are either single or form a reticulum which may be flaky and dense, with small pores like worm borings.

Specimen No. 15. A nearly globular mass which seems to have begun on the upturned edge of a flat pebble, and then to have partially rolled over. The calicles are of the typical shape, about 3·5 mm., but the wall-ridge is blunt. In the vertical section the septa are almost all very open lattice-work, a fact which may be correlated with greater thickness of the wall-elements. Geol. Dept. 48487.

Specimen No. 16. A small nearly spherical colony upon a very small pebble. Calicles small, the largest 3·5 mm., of the typical shape, with nearly straight wall-threads, and a certain number of primaries and secondaries rising directly from the thread in a very conspicuous manner. In the sections the septa are lattice-like, and the wall-reticulum, where developed, is as if composed of twisted flakes. Geol. Dept. 49575.

Specimen No. 17. A small colony encrusting a valve of *Arca biangula.* Calicles about 3 mm., rather deep and concave than shallow funnel-shaped, with the wall-ridges blunt and reticular (? abrased). The reticulum of slightly coarser texture than the septa. Geol. Dept. 48335.

Specimens Nos. 18 and 19. Two nearly globular or ovoid specimens, showing varying degrees of abrasion. Here and there shallow funnel-shaped calicles with low sharp walls may

* In Lonsdale's figure 5 *d* the striæ are figured either horizontal or sloping downwards (Dixon's 'Sussex,' pl. i.). Cf. Duncan's 'British Fossil Corals,' pl. iii. fig. 4, where this point is correct, but the wall is quite misrepresented.

be seen, but most of the walls are reticular, perhaps due to slight abrasion. Where most exposed the flaky worm-eaten character of the reticulum is very conspicuous, while the columella, which is inconspicuous in the surface calicles, becomes in the abrased parts a very large flaky spongework, more open than that of the walls. The septa, thin and delicate at the surface, are here very echinulate. These characters, with variations, seem to have belonged to the surface in Nos. 25 to 31. Echinulate septa are shown in the rough original figure given by Bowerbank (*Mag. Nat. Hist.*, Charlesworth, iv. (1840) p. 27), but no columellar tangle.
Geol. Dept. 48487.

Specimen No. 20. A worn and probably rolled fragment, to which a young Turbinolid is attached. If much worn, the smallness of the columella and the thinness of the walls are peculiar features. The latter consist at most of single rows of meshes. The septa appear to have been stout and slightly nodulated rather than echinulate. But the fact that another coral has attached itself to it shows that it must have been exposed to the action of water after death, and is probably somewhat altered. Geol. Dept. 48487.

Specimen No. 21. A small dome-shaped knob, with small calicles, the largest 3 mm., shallow funnel-shaped, differing from all the preceding in a tendency of the septa to be wavy and bent, and irregularly nodulated. The much thickened wall-thread is often reticular A few of the calicles suggest Duncan's figure of *Litharæa brockenhursti* ('British Fossil Corals, *Mon. Pal. Soc.* pl. vii. fig. 17). Geol. Dept. 48336.

Specimen No. 22. Half of a pear-shaped stock, about 2 cm. high, nearly enveloping a small pebble, showing a vertical section in which the septa are highly perforate. There is again a tendency for the septa to be wavy. Geol. Dept. 48487.

Specimen No. 23. A broken specimen, which appears to have been very symmetrically ovoid. The calicles about 4 mm. [? abrased]; the wall is flaky, and shows usually a single row of small meshes; its thickened thread is traceable in the vertical section. The columella is very conspicuous; the septa, nearly straight at the surface, are seen to be very perforate in the section. This is the specimen figured in Dixon's 'Sussex,' pl. i. fig. 5 *b*, *c* and *d*. Geol. Dept. 48334.

Specimens Nos. 24 and 25. Two large rounded specimens on flattened pebbles. The tops have been much abrased. The septa and skeleton extremely thin and delicate. The wall-reticulum is delicate, flaky, and sometimes 2 mm. and more thick, with very small meshes like worm-borings. The columellar tangle very conspicuous. At the sides, here and there, calicles occur like those described as typical (cf. No. 1). Geol. Dept. 49570.

Specimen No. 26. A fragment, showing portion of worn surface bounded by beautiful vertical sections. Calicles like the last, except that the septa are not thin and straight, but thick and slightly irregular. The walls, too, are perhaps more flaky and solid looking, the wall-meshes being very irregular in size. The walls as seen in vertical section are mostly solid, and the septa are largely laminate. Geol. Dept. 48335.

Specimen No. 27. Like No. 24 and No. 25, with extremely thin septa and skeletal wall-tissue, large calicles, largest 5 mm., and large columella. Geol. Dept. 48333.

Specimen No. 28. Obviously much abrased, calicles smaller than in No. 27, 4 mm., septa somewhat thicker, wall-reticulum closer and thicker. This is one of Lonsdale's original specimens figured in Dixon's 'Sussex,' 1850, pl. i. fig. 5, p. 139. Geol. Dept. 48333.

Specimen No. 29. Pl. X^b. fig. 5. Like No. 28; calicles still smaller, 3 mm., and walls somewhat denser. Geol. Dept. 48334.

Specimen No. 30. Pl. X^b. fig. 7. A fragment, and one of the most beautiful of all the specimens. It is doubtful whether the original surface has been abrased. Calicles large, 5 mm., fairly uniform. Septa delicate, but very frosted, and not more than 1 mm. long before they unite with an immense columellar tangle, which is a delicate reticulum of smooth flakes. The walls are of close flaky reticulum, as if finely worm-eaten. The vertical sections show the outer portions of the septa largely laminate, while the inner portions, which help to form the columella, are very perforate. Bowerbank's original figure was apparently intended to represent a specimen with walls and septa like these, *but without a columellar tangle*.
Geol. Dept. 48335.

Specimens Nos. 31 and 32. Two specimens, piled up almost into columns above their pebble bases. The wall-thread tends to thicken, and the septa to be wavy and irregular.
Geol. Dept. 1854.

142. Goniopora Hampshire (1).

[Brockenhurst, Hampshire (Oligocene, Headon Beds); British Museum.]

Litharœa brockenhursti, Duncan, British Fossil Corals, *Mon. Pal. Soc.*, Suppl. Part i. (1866) p. 49, pl. vii. figs. 16 and 17.

Description.—Form of stock unknown; massive

Calicles very unequal in size, the largest under 4 mm.; the walls are thin and seem to be composed of a stout gyrating thread of very irregular thickness, sometimes forming single meshes.

The septa very much thinner than the wall-thread, in three cycles arranged in the typical way, but the formula is obscured by the large columellar tangle. The primaries are perhaps a little more conspicuous than the rest. The septa are very irregularly and slightly echinulate, but very highly perforate, the pores being large and round and separated by thin nearly vertical and horizontal threads. The large columellar tangle is of flaky reticulum, and in the larger calicles (3·5 mm.) it may be 1·5 mm. across, in the smaller calicles it is not so conspicuous. The skeleton is exquisitely delicate and friable.

The single type specimen, figured by Martin Duncan, is only an irregular fragment, and, unfortunately, gives no clue to the original shape, nor to the characters of the calicles of the original surface. Duncan's figure and description give some of the appearances, but he did not discover that there are larger and more regular calicles with conspicuous columellar tangles, and altogether very unlike the small thin-walled nearly rectangular calicles which he figured.

This coral is closely allied to the forms of the same genus from Bracklesham Bay. The section of a calicle is not very unlike that of specimen 30 (see opposite page), only it is smaller, the septa are not so echinulate, and the wall-reticulum is less flaky. Geol. Dept. 49641.

Appendix to the English Gonioporæ.

Figures 15 and 15*a* on Plate XIV. refer to a specimen (Geol. Dept. R. 4821) which I mistook for one of the Goniopores with circular calicles, looking as if neatly punctured into the smooth convex surface of the corallum, each calicle having a rosette of six prominent pali-bearing septa (cf. Pl. I. fig. 2, Pl. III. fig. 9, Pl. IV. fig. 8, etc.). But Mr. R. Bullen Newton informs me that I have been accidentally misled as to the horizon and locality of the specimen, and that it rightly belongs to the Albian beds of Haldon Hill in Devonshire, and that it is probably more nearly related to the genus *Haldonia* of Duncan (Quart. Journ. Geo. Soc. XXXV. (1879), p. 91, pl. 8, figs. 2 and 3).

It certainly would be remarkable to find a cretaceous *Goniopora* showing a type of calicle-structure which on every count must be regarded as highly specialised (cf. Introd. p. 19, and p. 180 C.) and which is so far only known among recent forms. The decision rests upon the character of the walls; if these are perforate, then structurally the specimen must be regarded as a *Goniopora* whatever its horizon. Unfortunately the state of the preservation allows of no final decision on this point. What I took to be the signs of perforations may well be, as Mr. Newton thinks, accidental alterations due to the fossilisation. It would be unsafe, therefore, to make any use of this fossil in reference to the history of the genus. It will, for the present, serve to call attention to this type of calicle structure in *Goniopora*, and be a lesson as to the difficulty of unravelling coral genera, owing to the fact that corals built on essentially different plans may come to imitate one another so closely that only the most minute anatomical study can assign them their places in the system.

Group XI.—RUSSIA.

143. Goniopora Crimea (1).

[Biassula, near the river Katscha (Lower Cretaceous, Barremian); Museum of the Institute of Mines, St. Petersburg.]

Litharœa taurica, Eichwald, Lethæa Rossica, vol. ii. (1868) p. 165, pl. xi. fig. 1*a* and *b*.

Description.— Corallum thick, explanate, slightly convex, attached to large stocks of other genera.

Calicles polygonal, 5 mm. in diameter, very shallow. The walls are thin and reticular, without median thread, and (judging from the figure) consisting of a single row of nearly rectangular meshes. Septa in three cycles with traces of a fourth; the primaries and secondaries

are hardly distinguishable; thick near the walls, but very thin near the columellar tangle; drawn straight and separate in the figure, but described as slightly wavy and with the tertiaries fusing with the secondaries; perforate through their whole length, denticulate or granulate along their upper edges, and laterally echinulate. The columellar tangle is conspicuously reticular and hardly raised. Between it and the septa rudimentary pali sometimes occur.

Only one specimen, about 4 inches square and 1 inch thick, is known. The figures are not quite in harmony with the text. A wall reticulum consisting of a single row of long rectangular meshes, with no trace of median thread, is enough to suggest caution. The description of the rudimentary pali is not clear, while the figure gives no help.

Eichwald compared the coral with the Middle Eocene *Goniopora Sussex 1* (*"Litharœa Websteri"*), but says it was explanate and not spherical, a difference depending solely upon accidental conditions. *G. Sussex 1* was spherical or thick encrusting, according as the pebble on which it grew was small or large. The thicker wall and echinulate septa of the Crimean form were also supposed to differentiate it from *G. Sussex 1*. None of the Sussex forms show a wall reticulum like that figured for the Crimean specimen.

The most interesting point about this coral is that it is the very earliest known representative of the genus *Goniopora*. It is important to note that it is not very far removed from the ideal primitive Goniopore sketched in the Introduction. It differs, however, in a few points. The wall should have been a simpler reticulum, probably with a median thread, and the fusion of the septa should have been more pronounced.

The great gap between this solitary coral from the lower Cretaceous beds, and the supposed period of the greatest development of the genus in the early tertiaries, is by no means filled up by the three forms from the later Cretaceous beds of Austria-Hungary. Indeed until the gaps shown on the Geological Table, p. 168, are filled up, our knowledge of the genus must be regarded as very rudimentary.

GROUP XII.—SOMALILAND.

144. Goniopora Somaliland (1).

[Somali Plateau, in the Cherty Limestones, overlying the Nerinæa Limestones, above Miriya Pass, and around God-la-Yareh, south of Bur-dab (8° 30′ N; 46° 30′ E.) (Eocene); Coll. F. B. Parkinson; British Museum.]

Litharœa parkinsoni, Gregory, Quart. Journ. Geo. Soc. LVI. (1900), p. 37, pl. ii. figs. 13 and 14.

Description.—The corallum formed what appear to have been parts of short, somewhat flattened and rather angular stems, up to 25 mm. in breadth and 18 mm. thick; with smaller pieces of the same character, about 10 mm. thick.

Calicles 3–4 mm. in diameter, very shallow, not very sharply polygonal. Walls slightly but irregularly raised, here and there as a sudden ridge, occasionally with a median very zig-zag thread, but more often appearing as a pronounced, not very thick, reticulum. The 24 septa show traces of the typical fusions; they are rather long, wavy, sometimes appearing to run over the wall. The columellar tangle was not large, but appears to have been fairly clearly

differentiated, and here and there with traces of paliform knobs. A directive keel, running right across the calicles, often in the line of growth, seems to have been fairly common.

Dr. Gregory describes this coral as having in some calicles the 6 pali typical of *Goniopora*, and correctly refers them to the points of fusion of the septa (see diagram A, p. 21). As we have already learnt to expect (see p. 146), the pali are not very prominent in forms with large gaping calicles and pronounced reticular columellar tangles.

What appears to me to be of the greatest interest is the fact that the septa appear frequently to run over the walls from calicle to calicle, as indicated in Dr. Gregory's figure (l. c. Pl. II. 13). This character has, so far, only been recorded once, and then on what appears to be an abnormal patch on the single specimen of *G. Celebes 1*. It is shown in the enlarged photograph, Pl. IX. fig. 3.

If the calicles there shown were filled up with some matrix, and the columellar tangle not larger, but a little more compact, it would, I think, give a very fair impression of the calicles of this Somaliland form.

There are four specimens. One appears to be part of a thicker stem, and the rest are small shapeless angular lumps, which were probably parts of branchlets. They are too altered now to give us any idea of their original shapes.

a–d. Geol. Dept. R. 4838.

Another specimen described in the same paper by Dr. Gregory as *Litharœa colœ*, also from Somaliland, is certainly a perforate coral, but it is difficult to say, without more specimens, to what genus it should be assigned. Not only has it none of the better-known characters of *Goniopora* but it appears to have lost all trace of radial symmetry. Until a series is found, such as helped us to assign the place to *G. Red Sea 4*, it is wiser to suspend judgment. On account, however, of Dr. Gregory's claim that it belongs to this family, I propose to have it photographed for Vol. V., for, if a Poritid, it seems to me to have more claims to belong to *Porites* than to *Goniopora*.

Group XIII.—WEST INDIES.

It is very doubtful whether this group has any true existence. It is noteworthy that while the closely allied genus *Porites* is richly developed, both fossil and recent, over the West Indian area, there should be no recorded recent *Gonioporæ*, while the only known fossil which appears to be a *Goniopora* is not of a primitive type.

145. Goniopora? Antigua (1)1. (Pl. XIV. fig. 17.)

[Antigua (Miocene?); Museum Geol. Soc. London, and British Museum.]

Rhodarœa irregularis, Duncan, Quart. Jour. Geol. Soc. XIX. (1863), p. 426.
Stephanocœnia tenuis et intersepta, Duncan, op. cit. p. 423, Pl. xiv. 3*a*, 3*b*, and XX. (1864), p. 27.

Description.—Corallum massive, with polygonal calicles running straight, side by side, as nearly open tubes about 3·5 mm. in diameter. Walls thin, membranous, apparently

perforate, very zigzag, sometimes forming a delicate angular, but open-meshed, reticulum when seen from above. The 24 septa are very thin, and the primaries and secondaries meet in a large open columellar tangle. The tertiaries appear to end freely.

There is only one specimen, silicified throughout, and with the coral imbedded in the clear matrix. But there are reasons to doubt whether the original conditions have been preserved, and also whether it is a *Goniopora* at all. The thin zigzag walls and the septa are nowhere sharply defined when seen under a pocket-lens, and what appear to be the apertures in the walls have ragged irregular outlines. It looks as if the substance of the coral skeleton had been etched away; and, if so, there is a possibility of these apertures being secondary and accidental, and this alone would rule the specimen out of this genus. It is also characteristic of the Poritidæ that the bases of the calicles fill up with tissue so as to be only occasionally traceable through the corallum. Here they are long open tubes. Then, again, it is very rare to see the tertiary septa end freely, and, as a rule, it is not like *Goniopora* to have such rigid septa. There is a fluency in the skeleton of this genus, with hardly a single exception, which is in great contrast to the skeletal rigidity shown in this fossil; such subtle indefinable distinctions are often excellent guides. But even in the face of these difficulties we have to be true to our morphological analysis; and from this point of view I think that, on the whole, the balance of the direct structural evidence is in favour of its being a *Goniopora*: the thin zigzag membranous walls, occasionally forming a reticulum, the large columella, the 24 septa, are all so much positive evidence, while the existence of the pores in the walls points also in the same direction. The difficulties can perhaps be regarded as mere questions of degree.

The specimens belonging to the Geological Society are from the "Marl formation, the Inclined Beds and Chert" of Antigua, and from "the Silt of the Sandstone plain," San Domingo. They were placed by Duncan in the genera *Stephanocœnia* and *Rhodarœa*; with the former identification I cannot at all agree.

a. Geol. Dept. 1298.

Group XIV.—FORMS WITHOUT RECORDED LOCALITY.

On the method of designating such forms.

Forms without recorded locality present us with morphological facts which we cannot ignore. They cannot take their places in the geographical series, and hence cannot be designated by any geographical names. By using the letters of the alphabet to indicate the unknown locality, we can designate them sufficiently for purposes of reference. The letter *x* may stand for the country, and *a*, *b*, *c*, etc. for the other details. *Goniopora x a*, *x b*, *x c*, would mean members of the genus of whose locality we know absolutely nothing. If, however, the country is known but not the district, we can write *Goniopora Australia a*, *Goniopora France a*, *b*, *c*, etc., as we have already had to do on pages 64 and 145. In this final group we have no information whatever as to the localities of the specimens, and yet their morphological characters are of great interest—the interest in them indeed continues to increase the closer the many variations on the primitive type are studied.

In two cases (see *Goniopora x b* and *x c*) we have been able to suggest localities, our reasons being based solely upon morphological comparisons.

146. **Goniopora** *x a*. (Pl. VIII. fig. 4.)

This being very like the specimen *G. Java Sea 1*, has already been described under that heading. For the known distribution of its growth-form and type of calicle see Table III. B. p. 170 and Table IV. B. (*b*). *β*. p. 179. Zool. Dept. 51. 11. 14. 88.

147. **Goniopora** *x b*. (Pl. VIII. fig. 8; Pl. XIV. fig. 1.)

This is a worn pebble-shaped fragment, but appears in essentials of structure to be so like a Red Sea form, that it has been already sufficiently described, see *G. Red Sea 4*, p. 103. I know of no other recent *Goniopora* with such remarkable skeletal structure, and the probability is therefore very great that this came from the shores of that sea.

Zool. Dept. 1902. 9. 9. 15.

148. **Goniopora** *x c*. (Pl. IX. figs. 1 and 2; Pl. XIV. fig. 2.)

Description.—Corallum forms heavy masses, with smooth rounded tops and vertical or only slightly bulging sides. The mass is divided irregularly by deep perpendicular fissures about 1 cm. in width, and often cutting in laterally for a certain distance and not completely dividing the surface. The living layer extends some 9–10 cm. down the outside of the coral, but much less in the fissures.

Calicles small, average 2 mm.; 2–3 mm. deep, all over the top, 1 mm. or less at the sides. Immense numbers of young calicles opening on the top, with an intracalicular skeleton filling them to the top of their walls. They are thus in great contrast with the deep calicles all around them. Walls thin, except where young calicles are developing, mostly a single thin zigzag with one side sometimes thickened to an angular reticulum, built up of glassy threads. These run out into septal points, which on the top of the stock may be like rows of sharp hairs. They are short and wavy, and the radial arrangement is not very symmetrical. The typical formula is probably developed, but the septa are too short and lost too soon in the large columellar tangle to be easily made out. The tertiaries bend round very conspicuously to fuse with the secondaries at an angle of 45° or more, and enclose a space smaller but almost as conspicuous as the other large rounded interseptal loculi. The columellar tangle is built of very irregular glassy flakes. In the shallow young calicles it is usually a single ring uniting the *secondary* septa, with small pali rising from the points of union.

In the lateral calicles the skeleton is thicker, the walls more solidly reticular, and the short thicker septa early join the large columellar tangle, which may be a mere convex mass of open flaky reticulum, or flat with conspicuous paliform granules. In vertical sections the walls are seen to become thick and solid, the septa like short bars rather close together, and

the columellar tangle a flaky mass with large oval pores. In transverse section the interseptal loculi are seen to be large, but to be so irregular as hardly to appear in rings.

This *Goniopora* stands quite alone in its structural features, in the texture of the growing top which appears as if made of glassy threads, and in the septa which project from the sides of the deep calicles as hair-like glassy points. This glassiness, so different from the usual opaque character of the Madreporarian skeleton, deserves noting. Cf. *Montipora friabilis*, Vol. III. p. 138, also from some unknown locality.

In Dr. Brüggemann's MS. Catalogue this specimen was called *Porites limosa* Dana,* evidently owing to the general resemblance in its method of growth to that figured by Dana. This growth-form is not easy to unravel. It may perhaps be regarded as an irregular cluster of thick columnar growths, the columns being of irregular outline. A considerable number of large worm-tubes open on the surface.

There is one large mass (*a*) with a fissure which partially divides it into three lobes, and two fragments (which fit together) of another mass.

a, *b*, *c*. Zool. Dept. 56. 12. 18. 25.

149. **Goniopora** *sp. d.* (Pl. VIII. fig. 5.)

Description.—The corallum forms oval masses, with smooth upper surface, the adherent edges creeping closely round.

Calicles polygonal, vary greatly in size, average about 2·5 mm., with occasional double calicles 4 mm. across, conical or funnel-shaped, about 3 mm. deep, some at the top much deeper. Walls single, but coarse, thick and zigzag, very denticulate along their upper edges, septa in two cycles, very stout. Round the margin the 12 coarse thick septa project equally, but below the surface the rather thicker and coarsely-toothed primaries gradually slope inwards, and form very deep down the inconspicuous central tangle. There is no trace of the typical septal formula, and the radial arrangement is irregular. In the shallower lateral calicles the inner edges of the primaries seem to thicken, and seen from above simulate a rosette of pali, which are sometimes actually present, but they rise from the edges of the septa and not from a columellar tangle. With a pocket-lens faint traces of tertiary septa may be seen as slight prominences from the outer margins of the interseptal loculi. These are more fully developed in the large double (?) calicles.

There is a single massive oval specimen of this coral, about 9 cm. long by 6 cm. across. It appears to have been growing rather irregularly, as if it had been rolled over on to its side, so that the last living layer does not fit exactly over the one which preceded it. The coral is peculiar for the immense thickness and solidity of its skeletal elements as compared with the small size of the calicles. The thick prominent primaries sloping deep down into the conical calicles and the absence of a distinct columellar floor form a type of calicle with which we are already familiar (cf. *G. Loyalty Islands 1*, p. 42).

* Cf. Dana's figure, Zoophytes, Atlas, pl. lv. fig. 2.

The only other *Gonioporæ* showing such calicles without columellar floors even in the shallower lateral calicles are given in Table IV. B (*b*) *a*, p. 179.

In Dr. Brüggemann's MS. Catalogue this coral figures as "*Goniopora savignyi* Dana," of the Red Sea, an identification which is quite out of the question. A study of the table would lead one rather to believe that the specimen belongs to the Australian or Polynesian groups.

a. Zool. Dept. 1902. 9. 9. 16.

150. **Goniopora** *x e*. (Pl. VIII. fig. 7; Pl. XIV. fig. 3.)

Description.—Corallum forms an irregularly rounded, slightly flattened mass, either growing on a short thin stalk or enveloping some point of the substratum. Living layer extends right under to the area of attachment.

Calicles small, under 2 mm., deep, angular and polygonal. Walls very thin, zigzag, jagged, denticulate along the top and perforated with long oval pores, especially on the uppermost surface of the corallum. The walls are nowhere reticular, not even in the lateral calicles. Short stout septal spikes project irregularly from the edges of the wall, sometimes tending to be plate-like and exsert. Parts of three cycles very irregularly developed. Some distance below the edges of the walls, the primaries, as rows of blunt rods, begin to project further into the fossa, and still lower down, meet to form an open tangle often with a central passage. From these septa in the lateral calicles six paliform rod-like processes rise up high in the calicles, but are always a millimeter or so below the level of the walls. They often appear as simple septal teeth bent upwards towards the aperture. The texture of the coral is very stoutly trabecular.

There is only one specimen of this coral in the collection, which is about 6 cm. long, 4·5 across, and 3·5 high. It has been completely hollowed out by some organism (probably a sponge), which has removed all traces of the attachment, so that the stock must have become free. Instead of any attaching surface, there is a large round hole leading into the central cavity. The destroying organism made one breach in the top surface, and near this it has come so close to the surface that the calicles are open tubes, all the columellar tangle having been removed. A fine thread, probably that of a boring sponge, can be seen on looking through some of these open calicles.

It is worth noting that the upper surface of the stock shows no sign of having been corroded or even of having been worn by rolling.

Dr. Brüggemann named this *Rhodaræa gracilis*, M.-E. & H., and it must be admitted that in essential structure it bears some resemblance to *G. Red Sea 4*, to which he gave the same name. The walls are thicker, the calicles deeper and more pronounced, and the rod-like septal apparatus does not rise to the level of the wall as it does in *G. Red Sea 4*. On the other hand, the stouter wall is quite what we see in the worn pebble (*Goniopora x b*) described under *G. Red Sea 4*. It is most probable, therefore, that this coral is from the Red Sea, the general structure agreeing with that of the other forms recorded from that area, and only from there.

a. A small free stock hollowed out. Zool. Dept. 43. 3. 6. 110.

151. Goniopora *xf.* (Pl. VIII. fig. 6; Pl. XIV. fig. 4.)

Description.—Corallum forms small, rounded, oval or columnar knobs.

Calicles large, 3–4 mm., shallow, gaping, varying in depth, some mere concave depressions, others with perpendicular sides but with concave floors. The walls vary in thickness, and are a very spiky reticulum, the meshes of which are smooth round holes. This reticulum tends to surge up wherever it is at all thickened, e.g. at the angles. Three cyles of septa arranged in the typical manner; they are wavy, and tend to throw out sharp spike-like synapticulæ laterally. Seen from above the free upper parts of the septa taper to the finest points. In many parts of the stock the large columella is in sharp contrast with the rest of the calicle in texture, being a reticulum of thin flakes mostly parallel with the surface, and perforated with round holes. Here and there the septa run out over the surface of the columella, and form at times very jagged spiky knobs representing the pali.

The single specimen of this coral is a small column or knob attached to a *Spondylus*; it has been so attacked by foreign organisms, boring molluscs, sponges, etc., that its growth is perhaps not normal. In the type of growth, and in the general character of the calicles, it resembles *Goniopora Philippines 1*, see p. 67. In the melting down of the whole texture into a reticulum it comes very near *G. Samoa 1*, but its calicles are larger, deeper, and more pronounced. Further, as in *G. Philippines 1*, the radial symmetry of the calicles is very marked, whereas this is not the case in *G. Samoa 1*. A peculiar feature in this coral is worth noting: the texture of the walls is much stouter than that of the rest of the calicle; the septa taper away, and the reticulum of the columella is thin and delicate. (Table IV. E. p. 181.)

a. Zool. Dept. 1902. 9. 9. 17.

152. Goniopora *x g.*

Madrepora intersepta, Esper. Pflanz. Suppl. I. (1797) p. 99, pl. 79.

Description.—Corallum forms rounded knobs closely enveloping the tips of other corals, without free edges, the living layer growing close round the base. The calicles are polygonal, walls are low, fairly thick and flat topped, consisting of a single row of pronounced septal striæ. The 24 septa appear to fuse together. An irregular group of pali, apparently rising from a columellar tangle, occupies a considerable area in the middle of the shallow calicle.

This coral, from the "East Indian Seas," is certainly a *Goniopora*, and in the method of its growth, and in the character of its calicles, it recalls *Goniopora Great Barrier Reef 3*, only the calicles were apparently somewhat smaller. It is impossible to follow Milne-Edwards and Haime in making it one of the types of *Stephanocœnia* (Nat. Hist. Cor., ii. (1857) p. 265).

ANALYTICAL TABLES OF THE RESULTS

WITH OBSERVATIONS.

N.B.—The positions in these Tables of any of the forms above described can be found by consulting the Index.

* So far as the records make it clear.

TABLE I.—LIST OF GONIOPORÆ DESCRIBED IN THE FOREGOING CATALOGUE.

NO.	DESIGNATION AND LOCALITY	DEPTH	HORIZON	REFERENCE TO FIGURES	ORIGINAL SPECIMENS IN	PAGE
	I. Polynesia.					
1	*New Guinea 1*, Bay of Doreh	Shallow water		Voy. de l'Astrolabe, Zooph. Atl. pl. xvi. 9–11.	? Paris Mus.	36
2	*New Guinea 2* (?)				Paris Mus.	37
3	*New Ireland 1*, Holzhafen	Shallow water			Berlin Mus.	38
4	*Solomon Islands 1*, Balalai, Shortland Island.			Pl. I. fig. 1; Pl. XI. fig. 1	Brit. Mus.	38
5	*Solomon Islands 2*, Shortland Island			Pl. I. fig. 2; Pl. XI. fig. 2	Brit. Mus.	39
6	*Solomon Islands 3*, Shortland Island			Pl. I. fig. 3; Pl. XI. fig. 3	Brit. Mus.	40
7	*Solomon Islands 4*, Bougainville Island.				Berlin Mus.	41
8	*Queen Charlotte Islands* 1, Vanikoro			Voy. de l'Astrolabe, Zooph. Atl. pl. xvi. figs. 1–3.	Paris Mus.	41
9	*Loyalty Islands 1*, Sandal Bay, Lifu			Pl. I. fig. 4; Pl. XI. fig. 4	Camb. Univ. Mus.	42
10	*Fiji Islands 1* (?)			Dana's Zoophytes, Atl. pl. lvi. figs. 5*a*, *b*.	?	43
11	*Tonga Islands 1*, Tongatabu			Pl. I. fig. 5; Pl. XI. fig. 5	Brit. Mus.	44
12	*Tonga Islands 2*, Tongatabu			Pl. I. fig. 6; Pl. XI. fig. 6	Brit. Mus.	45
13	*Tonga Islands 3*, Tongatabu			Pl. I. fig. 7; Pl. XI. fig. 7	Brit. Mus.	46
14	*Samoa 1* (?)			Pl. I. figs. 8, 9; Pl. XI. fig. 8	Brit. Mus.	47
	II. Australia.					
15	*Great Barrier Reef 1*, Townsville.			Pl. II. fig. 1; Pl. XI. fig. 9	Brit. Mus.	48
16	*Great Barrier Reef 2*, Palm Island			Pl. II. figs. 2, 3; Pl. XI. fig. 10.	Brit. Mus.	49
17	*Great Barrier Reef 3* (?)			Pl. II. fig. 4; Pl. XI. fig. 11.	Brit. Mus.	50
18	*Great Barrier Reef 4* (?)			Pl. II. fig. 5	Brit. Mus.	51
19	*Great Barrier Reef 5* (?)			Pl. II. fig. 6	Brit. Mus.	52
20	*Great Barrier Reef 6*, Albany Passage.			Pl. II. figs. 7, 8; Pl. XI. fig. 12.	Brit. Mus.	53
21	*Great Barrier Reef 7*, Warrior Island.			Pl. II. fig. 9; Pl. III. fig. 1, 2; Pl. XII. fig. 1.	Brit. Mus.	53
22	*Great Barrier Reef 8* (?)			Pl. III. fig. 3; Pl. XI. fig. 13	Brit. Mus.	55
23	*Great Barrier Reef 9*, South of Wreck Bay.			Pl. III. fig. 4	Brit. Mus.	55
24	*Great Barrier Reef 10*, Thursday Island.			Pl. III. fig. 5; Pl. XII. fig. 2	Brit. Mus.	56
25	*Great Barrier Reef 11*, Torres Strait.			Pl. III. fig. 6; Pl. XI. fig. 14	Brit. Mus.	57
26	*Great Barrier Reef 12*, Warrior Reef.	Extreme low water		Pl. III. fig. 7, 8; also in Records Austr. Mus., vol. i. pl. xv. fig. 1–4, pl. xvi. fig. 1.	Brit. Mus. & Aust. Mus. Sydney	58
27	*North-West Australia 1*, Troughton Island.	Reef		Pl. III. fig. 9	Brit. Mus.	59
28	*North-West Australia 2*, Bassett-Smith Shoal, Holothuria Reef.	9 fathoms		Pl. IV. fig. 1; Pl. XI. fig. 15	Brit. Mus.	60
29	*North-West Australia 3*, Holothuria Bank.	15 fathoms		Pl. IV. fig. 2; Pl. XII. fig. 3	Brit. Mus.	61

NO.	DESIGNATION AND LOCALITY	DEPTH	HORIZON	REFERENCE TO FIGURES	ORIGINAL SPECIMENS IN	PAGE
30	*North-West Australia 4*, Holothuria Bank.	15 fathoms		Pl. IV. fig. 3; Pl. XII. fig. 4	Brit. Mus.	61
31	*North-West Australia 5*, Holothuria Bank.	15 fathoms		. . . . .	Brit. Mus.	62
32	*North-West Australia 6*, King's Sound.			Pl. IV. figs. 4, 5, 6; Pl. XII. figs. 5 and 6.	Brit. Mus.	63
33	*Australia a*, 'Mers de la Nouvelle Hollande.'			. . . . .	Paris Mus.	64
	III. Malay Archipelago.					
34	*Moluccas 1*, Amboyna.			Pl. IV. fig. 7 and Chall. Rep. xvi. pl. viii. figs. 7, 7*a*, 7*b*.	Brit. Mus.	65
35	*Celebes 1*, Talissé Island			Pl. IV. fig. 8; Pl. XII. fig. 7; also Pl. IX. fig. 3.	Cambridge	66
36	*Philippines 1*, Zamboanga.			Pl. IV. fig. 9; Chall. Rep. xvi. pl. xi. figs. 1, 1*a*.	Brit. Mus.	67
37	*Philippines 2*, Zamboanga.			Pl. V. figs. 1, 2	Brit. Mus.	68
38	*Philippines 3*, Santa Cruz Major Island, Zamboanga.	10 fathoms		. . . . .	Brit. Mus.	69
39	*Philippines 4*, Mactan Island			Pl. V. fig. 3	Brit. Mus.	70
40	*China Sea 1*, 'Mers de Chine'			. . . . .	Paris Mus.	70
41	*China Sea 2*, Macclesfield Bank	31 fathoms		Pl. V. fig. 4; Pl. XII. fig. 8	Brit. Mus.	71
42	*China Sea 3*, Macclesfield Bank	28 fathoms		Pl. V. fig. 5; Pl. XII. figs. 9, *a* and *b*.	Brit. Mus.	72
43	*China Sea 4*, South side of Itu Aba, Tizard Bank.	2 fathoms		Pl. V. fig. 6; Pl. XII. fig. 10	Brit. Mus.	72
44	*China Sea 5*, Macclesfield Bank	32–42 fathoms		Pl. V. fig. 7 and 8; Pl. XII. fig. 11.	Brit. Mus.	73
45	*Java Sea 1*, Billiton			. . . . .	Brit. Mus.	75
46	*Java Sea 2*, Valley of the Tjilanang, Ronga.		Upper Miocene	Novara Expedition, II. pl. ii. figs. 5*a*, *b*, *c*.	?	77
47	*Java Sea 3*, Valley of the Tjilanang, Ronga.		Upper Miocene	Novara Expedition, II. pl. ii. fig. 4	?	78
48	*Java Sea 4*, near Liotjitjangkang		Upper Miocene	Martin's Tertiärschicht. Java, pl. 25, figs. 14, 15, & pl. 26, fig. 9.	? Leyden Mus.	78
49	*Singapore 1*, (?) Rabbit Island			Pl. V. fig. 9; Pl. XII. fig. 12	Brit. Mus.	79
50	*Singapore 2* (?)			Pl. VI. figs. 1 and 2; Pl. XII. fig. 13.	Brit. Mus.	80
51	*Singapore 3*			Pl. VI. figs. 3 and 4; Pl. XIII. fig. 1.	Brit. Mus.	81
52	*Singapore 4*			Pl. VI. figs. 5 and 6; Pl. XIII. fig. 2.	Camb. & Brit. Mus.	82
53	*Singapore 5*, Rabbit Island			Pl. VI. figs. 7 and 8; Pl. XIII. fig. 3.	Camb. & Brit. Mus.	83
54	*Singapore 6*			Pl. XIII. fig. 4	Cambridge	84
	IV. Indian Ocean.					
55	*Ceylon 1*, Ramesvaram, Gulf of Manaar.			Pl. VI. fig. 9; Pl. XIII. fig. 5	Brit. Mus.	85
56	*Maldives 1*, Addu	32 fathoms		Pl. VII. fig. 1; Pl. XIII. fig. 6	Cambridge	86
57	*Maldives 2*, Hulule			Pl. VII. figs. 2 and 3; Pl. XIII. fig. 7.	Camb. & Brit. Mus.	87
58	*Maldives 3*			Pl. VII. figs. 4 and 5; Pl. XIII. fig. 8.	Cambridge	88
59	*Maldives 4*, Several Islands, see text.	Depths, see text.		Pl. VII. fig. 6; Pl. XIII. fig. 9	Camb. & Brit. Mus.	89
60	*Mauritius 1*			Pl. VII. figs. 7 and 8; Pl. XIII. fig. 10.	Brit. Mus.	90
61	*Seychelles 1*.			. . . . .	Paris Mus.	91

NO.	DESIGNATION AND LOCALITY	DEPTH	HORIZON	REFERENCE TO FIGURES	ORIGINAL SPECIMENS IN	PAGE
	V. India and Persia.					
62	*Sind 1*, Jakmari, Laki Range, Amri.	. . . .	Upper Cretaceous or Lower Eocene	Sind Fossil Corals, pl. ii. figs. 1–9.	Calcutta Mus.	92
63	*Sind 2*, S.W. of Lynyan, Ranikot Group.	. . . .	Lower Eocene . .	Sind Fossil Corals, pl. xi. figs. 11–13.	Calcutta Mus.	93
64	*Sind 3*, Jhirk, Ranikot Group .	. . . .	Lower Eocene . .	Sind Fossil Corals, pl. xiv. figs. 5, 6.	Calcutta Mus.	93
65	*Sind 4*, Maliri, Khotra . . .	. . . .	Upper Eocene . .	Sind Fossil Corals, pl. v. figs. 12, 13.	Calcutta Mus.	94
66	*Sind 5*, near Raduk	. . . .	Upper Eocene . .	Sind Fossil Corals, pl. xix. figs. 4, 5.	Calcutta Mus.	94
67	*Sind 6*, ? near Kurrachee. . .	. . . .	Eocene	. . . . .	Brit. Mus.	95
68	*Sind 7*, ? near Kurrachee. . .	. . . .	Eocene	. . . . .	Brit. Mus.	95
69	*India a*	. . . .	Eocene	. . . . .	Brit. Mus.	96
70	*Persia 1*, Lake Urmi	. . . .	Miocene . . .	. . . . .	. . . . .	96
71	*Persia 2*, Bajazid, Araxes Valley.	. . . .	Miocene . . .	Mem. Ac. Imp. Sci. Petersburg, 6° ix. figs. 12, *a–e*.	? St. Petersburg	97
72	*Persia 3*, Lake Urmi	. . . .	Miocene . . .	Pl. XIV. fig. 5	Brit. Mus.	97
73	*Persia 4*, Lake Urmi	. . . .	Miocene . . .	. . . . .	Brit. Mus.	98
	VI. Red Sea and Egypt.					
74	*Red Sea 1*, Koseir	. . . .	. . . . .	Pl. VIII. figs. 1, 2 ; Pl. XIII. fig. 12 ; Dr. Klunzinger's Korallenthiere, ii. pl. viii. fig. 23, pl. v. fig. 24.	Brit. Mus.	100
75	*Red Sea 2*	. . . .	. . . . .	. . . . .	Leyden Mus.	101
76	*Red Sea 3*, ? Koseir	Deep water on face of reef	. . . . .	Dr. Klunzinger's Korallenthiere, ii. pl. viii. fig. 24, pl. v. fig. 23.	Berlin Mus.	101
77	*Red Sea 4*	. . . .	. . . . .	Pl. VII. fig. 9 ; Pl. XIII. fig. 11 .	Brit. Mus.	102
78	*Red Sea 5*, ? Koseir	On edge of reef	. . . . .	Dr. Klunzinger's Korallenthiere, ii. pl. v. fig. 22.	Berlin Mus.	104
79	*Red Sea 6*, Rasal Mashiyed, Sinaitic Peninsula.	. . . .	Raised beach . .	Pl. VIII. fig. 3 ; Pl. XIII. fig. 13	Brit. Mus.	104
80	*Egypt 1*, El-guss-abu-Said. . .	. . . .	Lower Eocene . .	. . . . .	? Munich	105
81	*Egypt 2*, Wadi-Ramlieh, Arabian Desert.	. . . .	Upper Tert. . .	. . . . .	Berlin Mus.	106
82	*Egypt 3*, Dungul Wells, Desert .	. . . .	Lower Eocene . .	Geol. Mag. v. 1898, pl. viii. 7 and ix. 6.	Cairo & Brit. Mus.	106
	VII. Italy.					
83	*Vicenza 1*, San Urbano, Montecchio Mag.	. . . .	Middle Eocene .	Catullo's Corals of Venetian Alps, 1856, pl. xvii. fig. 6 A, B.	? Mus., Univ. Padua.	107
84	*Vicenza 2* Croce Grande, S. Giovanni Ilarione.	. . . .	Middle Eocene .	. . . . .	? Pisa	108
85	*Vicenza 3*, Monte Grumi, Castel Gomberto.	. . . .	Oligocene . . .	Reuss, Wiener Denksch. 1868, pl. xv. fig. 8.	. . ? . .	108
86	*Vicenza 4*, Crosara, Marostico .	. . . .	Oligocene . . .	. . . . .	. . ? . .	109
87	*Vicenza 5*, Crosara, Marostico .	. . . .	Oligocene . . .	Reuss, Wiener Denksch. 1869, pl. xxvi. 4 *a*, *b*.	. . . . .	109
88	*Vicenza 6*, Crosara, Marostico .	. . . .	Oligocene . . .	Reuss, Wiener Denksch. 1869, pl. xxvii. fig. 2.	. . ? . .	110
89	*Vicenza 7*, Crosara, Marostico .	. . . .	Oligocene . . .	Reuss, Wiener Denksch. 1869, pl. xxvi. figs. 1–3, xxvii. fig. 1.	. . . . .	110
90	*Vicenza 8*, S. Giovanni Ilarione .	. . . .	Middle Eocene .	Reuss, Wiener Denksch. 1874, xl. figs. 9, 10.	. . ? . .	111
91	*Vicenza 9*, S. Giovanni Ilarione .	. . . .	Middle Eocene .	. . . . .	. . ? . .	112

NO.	DESIGNATION AND LOCALITY	DEPTH	HORIZON	REFERENCE TO FIGURES	ORIGINAL SPECIMENS IN	PAGE
92	*Vicenza 10*, Crosara, Marostico		Oligocene	Angelis, Atti R. Accad. Lincei, i. 1895, fig. 10 in text.	Geol. Mus. Rome	113
93	*Vicenza 11*, Crosara, Marostico		Oligocene	Angelis, Atti R. Accad. Lincei, i. 1895, fig. 7 in text.	Geol. Mus. Rome	113
94	*Vicenza 12*, Fontana della Bove		Oligocene	Pl. XIV. fig. 6	Brit. Mus.	114
95	*Vicenza 13*, "Montecchio"		? Oligocene		Geol. Mus. Rome	115
96	*Verona 1*, Ronça		Upper Eocene	Reuss, Wiener Denksch. 1874, pl. xl. fig. 9, 10.	?	115
97	*Verona 2*, Ronça		Upper Eocene		Geol. Mus. Rome	115
98	*Alessandria 1*, Asti		Pliocene	Michelin, Icones, pl. 13, fig. 9 *a*, *b* (?)	Turin Mus.	116
99	*Alessandria 2*, Tortona		Upper Miocene	Sismonda, Pal. Piedmont, 1871, pl. ix. figs. 1, 2.	?	116
100	*Alessandria 3*, Stazzano		Miocene		Geol. Mus. Rome	117
101	*Turin 1*		Middle Miocene	Michelin, Icones, pl. 13, fig. 9 *a*, *b*		117
102	*Turin 2*		Middle Miocene		Geol. Mus. Rome	118
103	*Turin 3*		Middle Miocene	Sismonda, Pal. Piedmont, 1871, pl. ix. figs. 1, 2.	?	119
104	*Genoa 1*, Dego		Upper Oligocene		Turin	119
105	*Genoa 2*, Sassello		Upper Oligocene		?	120
106	*Genoa 3*, Sassello		Upper Oligocene	Angelis, Atti R. Accad. Lincei, i. 1895, fig. 9 in text.	Geol. Mus. Rome	120
107	*Genoa 4*, Dego		Upper Oligocene	Angelis, Atti R. Accad. Lincei, i. 1895, fig. 8 in text.	Geol. Mus. Rome	121
108	*Genoa 5*, Dego		Upper Oligocene		Geol. Mus. Rome	121
	VIII. Austro-Hungary.					
109	*Vienna Basin 1*, Potzleindorf		Miocene	Reuss, Haidinger's Natur. Abh. ii. 1848, pl. v. fig. 3.	Vienna	122
110	*Vienna Basin 2*, Stockerau		Miocene	Reuss, Haidinger's Natur. Abh. ii. 1848, pl. v. fig. 4.	K. Mont. Mus. Vienna.	123
111	*Vienna Basin 3*, Niederleis		Miocene	Reuss, Wiener Denksch. 1872, pl. xvii. figs. 3, 4.	H. Min. Cab. Vien.	124
112	*Vienna Basin 4*, Forchtenau		Miocene	Reuss, Wiener Denksch. 1872, pl. xvii. figs. 5, 6.	H. Min. Cab. Vien.	124
113	*Oberburg 1*, Neustift		Oligocene	Reuss, Wiener Denksch. 1864, pl. viii. figs. 7, 8.	?	125
114	*Oberburg 2*, Neustift		Oligocene	Reuss, Wiener Denksch. 1864, pl. viii. fig. 9.	?	126
115	*Koritzan 1* (Bohemia)		Upper Cretaceous.	Reuss, Verst. Böhm. Kreide, 1845, pl. xliii. fig. 3; Posta, Anth. Böhm. Kreide, 1887, pl. i. fig. 4 *a*, *b*.	? K. Mus. Prague	126
116	*Koritzan 2*		Upper Cretaceous.		K. Mus. Prague	127
117	*Bilin 1* (Bohemia)		Upper Cretaceous.	Posta, Anthozoen d. Böhm. Kreide, 1887, pl. i. fig. 6.	K. Mus. Prague	127
	IX. France.					
118	*Dax 1*		Miocene		Paris	128
119	*Dax 2*		Miocene		Paris	129
120	*Dax 3*		Middle Eocene	Pl. IX. fig. 4	Brit. Mus.	129
121	*Dax 4*		Oligocene		Brit. Mus.	130
122	*Gironde 1*		Oligocene	Pl. IX. fig. 5; Pl. XIV. fig. 8	Brit. Mus.	130

NO.	DESIGNATION AND LOCALITY	DEPTH	HORIZON	REFERENCE TO FIGURES	ORIGINAL SPECIMENS IN	PAGE
123	*Gironde 2*, Peloua, near Bordeaux		Lower Miocene	Pl. IX. fig. 6; Pl. XIV. fig. 7	Brit. Mus.	132
124	*Paris Basin 1*, Cuise-la-Motte, Compiègne, Oise.		Lower Eocene	Michelin, Icones, pl. 44, figs. 7 *a*, *b*.	Paris	132
125	*Paris Basin 2*, Parnes and Valmondois.		Middle Eocene	Michelin, Icones, pl. 44, fig. 2 (see also Pl. IX. fig. 7; Pl. X. fig. 1 of this Catalogue).	(A specimen in Brit. Mus.)	133
126	*Paris Basin 3*, Auvers		Upper Eocene		Paris	134
127	*Paris Basin 4*, "Grignon, Montmirail, Parnes, etc."		Middle Eocene	Michelin, Icones, pl. 44, fig. 3 (see also Pl. X. figs. 2, 3, 4).	(3 specimens in Brit. Mus.)	134
128	*Paris Basin 5*, ? Chaussy		Middle Eocene	Pl. X. fig. 5; Pl. XIV. fig. 9	Brit. Mus.	135
129	*Paris Basin 6*, Chaussy		Middle Eocene	Pl. X. fig. 6; Pl. XIV. fig. 10	Brit. Mus.	136
130	*Paris Basin 7*, ? exact locality		Eocene	Pl. X. fig. 7	Brit. Mus.	136
131	*Paris Basin 8*, Parnes		Middle Eocene	Pl. X. fig. 8	Brit. Mus.	137
132	*Paris Basin 9*, ? exact locality		Eocene	Pl. X. fig. 9; Pl. XIX. fig. 11	Brit. Mus.	138
133	*Paris Basin 10*, Auvers		Upper Eocene	Pl. X^a. figs. 1, 2	Brit. Mus.	138
134	*Paris Basin 11*, Auvers		Upper Eocene	Pl. X^a. fig. 3; Pl. XIV. fig. 12	Brit. Mus.	139
135	*Paris Basin* 12, Le Fayel, near Marines.		Upper Eocene	Pl. X^a. fig. 4	Brit. Mus.	141
136	*Paris Basin 13*, Auvers		Upper Eocene	Pl. X^a. fig. 7; Pl. XIV. fig. 13	Brit. Mus.	141
137	*Paris Basin 14*, ? exact locality		Eocene	Pl. X^a. figs. 5, 6, 8; Pl. XIV. fig. 14.	Brit. Mus.	142
138	*Coutances 1*, Hautville		Middle Eocene	Pl. X^b. fig. 1; Pl. XIV. fig. 16	Brit. Mus.	143
139	*Coutances 2*, Hautville		Middle Eocene	Pl. X^b. fig. 2	Brit. Mus.	144
140	*France a*		? Middle Eocene	Pl. X^b. fig. 3	Brit. Mus.	144
	X. England.					
141	*Sussex 1*, Bracklesham Bay		Lower Eocene	Charlesworth's Mag. iv. 1840, figs. A, B in text; Brit. Foss. Corals, 1850, pl. vii. figs. 1 *a*, *b*; Dixon's Sussex, pl. i. fig. 5 *a*–*e*; Brit. Foss. Corals (Supp.) pl. iii. fig. 4 (see also Pl. X^b. figs. 4, 5, 6, 7 of this Catalogue).	32 specimens in Brit. Mus.	147
142	*Hampshire 1*, Brockenhurst		Oligocene	Brit. Foss. Corals (Supp.) 1866, pl. vii. figs. 16, 17.	Brit. Mus.	152
	XI. Russia.					
143	*Crimea 1*		Lower Cretaceous.	Eichwald's Lethæa Rossica, pl. xi. figs. 1 *a*, *b*.	St. Petersburg	153
	XII. Somaliland.					
144	*Somaliland 1*, North edge of Somali Plateau.		Eocene	Quart. Journ. Geol. Soc. lvi. 1900, pl. ii. figs. 13, 14.	Brit. Mus.	154
	XIII West Indies.					
145	*Antigua 1*		? Miocene	Pl. XIV. fig. 17	Brit. Mus.	155

NO.	DESIGNATION AND LOCALITY	DEPTH	HORIZON	REFERENCE TO FIGURES	ORIGINAL SPECIMENS IN	PAGE
	XIV. From Unknown Localities.					
146	*Goniopora xa*			Pl. VIII. fig. 4	Brit. Mus.	157
147	*Goniopora xb*			Pl. VIII. fig. 8; Pl. XIV. fig. 1	Brit. Mus.	157
148	*Goniopora xc*			Pl. IX. figs. 1, 2; Pl. XIV. fig. 2	Brit. Mus.	157
149	*Goniopora xd*			Pl. VIII. fig. 5	Brit. Mus.	158
150	*Goniopora xe*			Pl. VIII. fig. 7; Pl. XIV. fig. 3	Brit. Mus.	159
151	*Goniopora xf*			Pl. VIII. fig. 6; Pl. XIV. fig. 4	Brit. Mus.	160
152	*Goniopora xg*			Esper, Pflanzenthiere, Suppl. I. p. 99, pl. 79.	?	160

The above is a fairly complete list of all the known forms of *Goniopora*. In the foregoing pages, however, evidence in abundance has been given that it can only be regarded as an introduction to our knowledge of the genus. Many new forms may be expected from deeper water. There are vast gaps in the geological record, not to mention the reefs from which we have no specimens at all. Those which we have are isolated and fragmentary, that is, seldom in series, which alone offer any chance of discovering lines of variation (*see description of G. Red Sea 4*). But in addition to those which have not yet been discovered at all, it is certain that great numbers of recent and fossil forms must at the present moment be stored in the museums of Europe * with various "specific" names attached, names whose chief use has been protective—specimens dignified with a name receive more care than those which have none. These can all be worked out now, and the results simply added to those here obtained.

Again, it is hardly possible that I have seen all the stray notices or even records which are buried in the pages of palæontological publications; most of these would, however, be recovered if only the specimens in the museums were worked out.

The following is a supplementary list of localities at which Poritids, many of them certainly members of this genus, have been noted.

Supplementary List of Localities.

Persia (see p. 96). Islands of Lake Urmi; in the limestone floor of the Great Cave of Maku; at Malishkent (?). As rounded nodules.

Egypt (see p. 106). Branching forms occur in Lower Tertiary beds, on the southern slope of the Mokattam, at the entrance to the Wadi Dugla, and on the Western Island of the Birket-el-Qurūn in the Fayūm. See also foot-note below.

Island of Rhodes (see p. 125). Encrusting.

Italy (see p. 125). Bianchi near Messina—frequent; Sogliano al Rubicone (Prov. Forli). Encrusting.

Austro-Hungary (see p. 122). In the Leithakalk of St. Nicholai and Gamlitz, and at Gradische (Styria); Mattersdorf (Hungary); Potzleindorf, Grund, Enzesfeld, Niederleis, Nodendorf and Kaladorf (Austria); Nicholsburg and Kostel (Moravia); Rudelsdorf (Bohemia). All encrusting.

In Leithakalk "des Rauchstallbrun Grabens bei Baden."

France (p. 118). At the mouth of the Rhone.

* A fine Lower Eocene specimen of *Litharæa* (= *Goniopora*) showing the primitive growth-form, from the Farafra Oasis, Egypt, has just been shown to me by Mr. R. Bullen Newton. It is the property of the Egyptian Geological Survey, and is especially interesting because all the known Egyptian forms are either of the primitive type or branching.

TABLE II.—SURVEY OF THE GEOGRAPHICAL AND GEOLOGICAL DISTRIBUTION OF THE KNOWN FORMS OF GONIOPORA.

	Localities	Lower Cretaceous	Upper Cretaceous	Eocene	Oligocene	Miocene	Pliocene	Pleistocene	TOTAL Fossil	TOTAL Recent
Polynesia	New Guinea								..	2
	New Ireland								..	1
	Solomon Islands								..	4
	Queen Charlotte Isls.								..	1
	Loyalty Islands								..	1
	Fiji Islands								..	1
	Tonga Islands								..	3
	Samoa								..	1
Australia	Great Barrier Reef								..	12
	North-West Australia								..	6
	Unknown Locality								..	1
Malay Archipelago	Moluccas								..	1
	Celebes								..	1
	Philippines								..	4
	China Sea								..	5
	Java Sea					*** (upper)			3	1
	Singapore								..	6
Indian Ocean	Ceylon								..	1
	Maldives								..	4
	Mauritius								..	1
	Seychelles								..	1
India & Persia †	Sind		* ? upper	******					7	..
	Unknown Locality (India)			*					1	..
	Persia †					****			4	..
Red Sea & Egypt †	Red Sea							*	1	5
	Egypt †			**	* ? "ober Tetiär-schichten"				3	..
Italy †	Vicenza			****	*********				13	..
	Verona			** (upper)					2	..
	Alessandria					**	*		3	..
	Turin					*** (middle)			3	..
	Genoa				***** (upper)				5	..
Austro-Hungary †	Vienna Basin					****			4	..
	Oberburg				**				2	..
	Koritzan		** (upper)						2	..
	Bilin		* (upper)						1	..
France †	Dax			* (middle)	*	**			4	..
	Gironde				*	* (lower)			2	..
	Paris Basin			* (lower) ******* (mid.) **** (upper) *** (?)					14	..
	Coutances			** (middle)					2	..
	Unknown, France			* ? middle					1	..
England	Sussex			* (lower)					1	..
	Hampshire				*				1	..
Russia	Crimea	*							1	..
East Africa	Somaliland			*					1	..
	Unknown Localities								..	7
		1	4	35	20	19	1	1	81	70

Total Records 151

The single doubtful West Indian form is omitted from this list: on the other hand, many of the localities mentioned at the end of Table I. where fossil Poritids have been merely observed, will have to be added when we know whether they are *Porites* or *Goniopora*.

† See supplementary list of localities at the end of Table I.

Table III.—A SURVEY OF THE DISTRIBUTION OF THE GROWTH-FORMS.

[N.B.—On Table I. will be found references to all the published figures illustrative of these forms.]

In previous volumes of the Coral Catalogue, the usual practice of assuming that the growth-form must be the leading taxonomic character has been more or less closely followed. I have given reasons, in the Introduction, p. 32, for doubting the correctness of this assumption. We do not know, for instance, whether the variations in the form of the calicles go first and cause the variations in the form of the colony, or *vice versa*. The necessity of choosing between these alternatives is avoided in this volume, and the specimens are arranged in an order based upon the one certain fact we know about them, viz. where they occur on the earth's surface. A complete justification for this departure from the usual plan is afforded by the following survey. However excellent the growth-form as a tentative taxonomic character may ultimately prove to be, this table shows how completely it would fail us in the present state of our knowledge. We cannot apply it for the simple reason that in a very large proportion of cases the necessary data are not forthcoming. Only in the case of the recent forms, when the specimens are whole, can the method of growth be discovered, and even then it is often possible for the same result to have been reached along different lines. In fact, only series of specimens can give us accurate information. When, therefore, we have to deal with a collection of recent and fossil forms, many of the former and most of the latter being mere fragments, the growth-form as a taxonomic character of any but the very roughest kind is clearly impracticable. We are even at times at a loss to decide as to which of the three rough divisions used by earlier authors, massive, encrusting, or ramose, individual specimens belong.*

After many vain attempts to make the best of the material contained in the descriptive part of this Catalogue, I have decided to give as exact a classification according to growth-form as I can of all those representatives of the genus in which this character can be approximately defined, and then at the end of each division to give a list of others which may possibly belong to it, but which cannot for certain be brought under any of the headings. These latter are nearly 50 per cent. of the whole number. It is, I take it, more instructive and more useful for future work on the genus, to make a start with an ideal table, however incomplete and fragmentary, than to pitch the scheme at a lower level simply in order to make

* Prof. Bell wrote in 1895 (Journ. R. Micro. Soc., p. 149): "It becomes at once obvious that it is impossible to frame anything like a satisfactory diagnosis of any coral of encrusting habit, unless a piece of some size is at the disposal of the describer, while it is no less clear that it would be no difficult task to give different specific names to pieces which might be shown by a larger example to be but parts of one 'stupendous whole.'"

it appear completer. Time will doubtless add to the number of the headings, and diminish the number of records whose places cannot be fixed.

The divisions in the following Table are based upon a somewhat more detailed analysis of the growth-forms than that given in the Introduction.

A. *Plano-convex.*

This is the primitive growth-form of *Goniopora*. It is open to question how far this simplest of all growth-forms persisted as the definitive shape of adult colonies; in individual cases it is impossible to say whether the specimen is not merely an earlier stage in the development of some other form. Nevertheless, certain fossil *Gonioporæ* are only known with this shape of colony, and we assume that in these cases it was definitive. Cf. the lowest colony in Diagram A, p. 24.

G. Sind 1.
G. Sind 2.
G. Sind 3, with irregular outline.
G. Egypt 3.
G. Vicenza 11.

The following four belong to the Paris Basin group where, probably owing to the unfavourable conditions, e.g. the presence of sand, most of the forms remained small. In these the primitive growth-form was frequently modified by having to encrust small fragments of shells, and even apparently to wrap round the stems of weeds.

G. Paris Basin 1, described as hemispherical.
G. Paris Basin 4. This apparently encircled the perishable stems of Algæ.
G. Paris Basin 14. Apparently a normal growth which was being killed down by partial submergence in sand. Its tip seems as if starting a fresh growth.
G. Coutances 2. Probably distorted by encrusting small foreign bodies.

Doubtful—probably young growth-stages:—
G. North-West Australia 4.
G. Verona 2.
G. Vienna Basin 2.

B. *Hemispherical.*

This is the simplest variation on the primitive Plano-convex, and due to an increased growth in height of the calicle walls. Diagram B, p. 24.

G. Great Barrier Reef 6.
G. Java Sea 1.
G. Maldives 4.
Goniopora xa.

The Hemispherical passes easily (*a*) by rapid growth of the central calicles into the columnar; (*b*) by rapid growth of all the calicles, even those round the edges, into the massive globular or massive and irregular. There will always therefore be a number of specimens which seem to be hovering between these different phases, and which have to be assigned places provisionally.

Doubtful:—

G. Australia a.
G. Vicenza 3.
G. Singapore 6, appears to be passing into the columnar.
G. Genoa 1.
G. Genoa 2.

C. *Columniform.*

We may perhaps distinguish five types of Columniform *Gonioporæ*.

The first (*a*) might be called pseudo-columnar, for the columns are not due to the direct continuous growth of a colony, but to the gradual piling up of colonies, the successive edges of which remain traceable. Diagram A, p. 24.

G. China Sea 4 may have been built up in this way.

b contains those forms which rise into stout round-topped columns without the formation of free edges, and without any great increase in thickness.

G. New Ireland 1.
G. Fiji Islands 1.
G. Great Barrier Reef 11.
G. Singapore 2.
G. Ceylon 1.

Doubtful:—

G. Singapore 6. This seems like a transition between the hemispherical and the columnar.
G. New Guinea 2.

c contains those columnar forms which are due to the sudden shooting up of the central portion of a colony by the rapid growth of the calicles in height. Diagram E, p. 24.

G. Solomon Islands 1. This coral forks; but the stem below the fork must have shot up as a thin erect column.

d. This differs from *c* in that the column is not the growth of a single colony, but groups of columns rise irregularly and adventitiously from the surface of an otherwise purely explanate stock by the sudden proliferation of groups of calicles. In the genus *Montipora*, in which the cœnenchyma reaches a climax in its development, such sudden upbursts are very common (see Vol. III. of this Catalogue), but so far only one instance is known in *Goniopora*.

G. Mauritius 1.

e is the expanding sheaf formation which usually results in columns, but is peculiar and important enough to be described under a heading of its own.

D. *Expanding Sheaf Formation.*

This modification of the primitive plano-convex is the most peculiar of all the growth-forms of *Goniopora*. It is hardly a modification of the true oval, because it is apparently due to great rapidity of calicular growth, although it may lead to the formation of oval stocks. It appears to be due to such rapid growth of the walls and septa in the central calicles of the

stock that they rise as bundles of twisted lamellæ, the bundles expanding as they rise. The form which results is usually columnar, but may be bluntly conical. Cf. Diagram D, p. 24.

G. Maldives 2.
G. Maldives 3.
G. Red Sea 1.
G. Red Sea 2.
G. Red Sea 3.
G. Red Sea 4.
G. Red Sea 6.

Doubtful :—

G. Great Barrier Reef 3. Oval, but due to great rapidity in calicular growth, which is not the case in the oval growth-form proper (see below).
G. Seychelles 1.
G. Singapore 3.
G. Tonga Islands 3. A flat-topped, shallow, inverted cone.
G. Paris Basin 13. This is even more doubtful than *G. Tonga Islands 3.*

E. *Branching.*

Branching may be produced along at least two quite different lines (*a*) by the forking and diverging of thin columns (Diagram E, p. 24), and (*b*) by the running out, curling up and subsequent proliferation of lobes from the edges of explanate stocks. This latter is rare.

(*a*).....*G. Singapore 1.*
G. Singapore 5.
G. China Sea 5. But perhaps belongs to (*b*) below.
G. Persia 2.
G. Vicenza 1.
G. Vicenza 2.
G. Vicenza 7.
G. Vicenza 12.
G. Verona 1.
G. Vienna Basin 3.
G. Dax 1.

Doubtful :—

G. Sind 5.
G. Oberburg 1.
G. Oberburg 2.
G. Somaliland 1.
G. Egypt 1.
G. Vicenza 8.
G. Vicenza 10.
G. Vicenza 13.

(*b*)....The only specimen which shows this beyond doubt is

G. Great Barrier Reef 12.
G. Great Barrier Reef 1 does not actually branch, but shows how such branching can be started by the curling up of marginal lobes.

Doubtful:—

G. China Sea 5. If this belongs here, the explanate phase is more completely obscured than in *G. Great Barrier Reef 12.*

F. *Massive.*

Massive forms result from the young colony thickening more rapidly than its base expands, and we get forms which are (*a*) regular, namely regularly rounded and regularly oval; (*b*) irregular, namely irregularly lobate and pulvinate.

(*a*) Regularly massive:—

Rounded, mostly flat topped, produced by continuous *regular* thickening of the stock, its width being equal to or greater than the height; edges closely encrusting.

G. New Guinea 1. Called hemispherical, but with narrow base.
G. Solomon Islands 2.
G. Solomon Islands 3.
G. Queen Charlotte Islands 1.
G. Great Barrier Reef 7.
G. Great Barrier Reef 10.
G. North-West Australia 1.
G. Celebes 1.
G. Philippines 2.
Goniopora x d.
Goniopora x e.

Doubtful:—

G. Solomon Islands 4.
G. North-West Australia 5.
G. China Sea 4.
G. Koritzan 1.
G. Koritzan 2.
G. Bilin 1.
G. Paris Basin 5.
G. Paris Basin 6.
G. Paris Basin 9.
G. Sussex 1.

Oval, produced by regular continuous growth, but the height is greater than the width; it differs apparently from the expanding sheaf growth in not being due to rapid growth of the walls and septa. Rare.

G. Philippines 1.
Goniopora x f.

Doubtful:—

G. Persia 4.
G. Great Barrier Reef 3. May belong to the expanding sheaf formation.
Goniopora x g.

(*b*) Irregularly massive :—

Lobate; the surface of the stock swells up irregularly owing to uneven growth of the calicles.

G. Great Barrier Reef 2.
G. North-West Australia 6. Perhaps belonging to the Globular division.
G. Singapore 4.
G. Sind 4.
Goniopora xc.

Doubtful :—

G. Java Sea 4.
G. Persia 1.
G. Persia 3.
G. Egypt 2.
G. Turin 3.
G. Vienna Basin 1.

Pulvinate, produced by discontinuous growths, each cushion-shaped colony bulging out from the top of that which preceded it. Diagram C, p. 24.

G. Tonga Islands 1.
G. Tonga Islands 2.
G. Moluccas 1.

Doubtful :—

G. Loyalty Islands 1.
G. Great Barrier Reef 4.
G. Great Barrier Reef 8.
G. Great Barrier Reef 9.

Massive of unknown form.

G. Great Barrier Reef 5.
G. Philippines 4. Perhaps belonging to division *G b*.
G. China Sea 1.
G. Java Sea 2.
G. Java Sea 3.
G. Sind 6.
G. Sind 7.
G. India a.
G. Vicenza 4.
G. Vicenza 5.
G. Vicenza 6.
G. Vicenza 9.
G. Alessandria 2.
G. Alessandria 3.
G. Turin 1. Perhaps belongs to the thick encrusting group.
G. Turin 2.
G. Genoa 1. Perhaps hemispherical.
G. Genoa 4.
G. Vienna Basin 2. Perhaps to division A.

G. Dax 2.
G. Dax 3.
G. Dax 4.
G. Gironde 1.
G. Gironde 2.
G. Paris Basin 3. Perhaps thick encrusting.
G. Paris Basin 7.
G. Paris Basin 10.
G. Paris Basin 12.
G. France a.
G. Hampshire 1.
? G. Antigua 1.

G. *Explanate.*

Produced by the expansions of the primitive colony mainly round the edges. According as there is any growth in thickness or not we obtain (*a*) thick, or (*b*) thin colonies, mostly encrusting; the very thin sometimes expand freely.

(*a*)....Thick encrusting. This may easily become irregularly massive :—

G. Alessandria 1.
G. Turin 1.
G. Vienna Basin 4.
G. Crimea 1.

Doubtful :—

G. Philippines 4.
G. Java Sea 2.
G. Paris Basin 3.
G. Paris Basin 11.

(*b*).....Thin :—

G. Great Barrier Reef 1. See also under E *b*.
G. North-West Australia 2.
G. North-West Australia 3.
G. China Sea 2.
G. China Sea 3.
G. Maldives 1.
G. Mauritius 1. Columns rise from its surface.
G. Red Sea 5.
G. Genoa 3
G. Genoa 5.
G. Paris Basin 2.
G. Paris basin 8.

H. *Forms whose method of growth cannot yet be defined.*

G. Samoa 1. ? Columnar.
G. Vicenza 10. ? Branching.
G. Coutances 1. ? Oval, drawn out into finger-shaped knobs which may have waved about at the tips of weeds.

Table IV.—ANALYSIS AND DISTRIBUTION OF THE MORE EASILY DEFINABLE TYPES OF CALICLE.

One result of the survey of all the known specimens of *Goniopora* contained in the foregoing pages is to enable us to differentiate certain fairly well marked types of calicle. At the outset this seemed hopeless on account of the multitude of minute structural variations in wall, septa, columella and pali. Quantitative distinctions were out of the question,* while qualitative distinctions seemed to baffle definition. Further practical difficulties may be mentioned in the facts (1) that the calicles of many fossil forms are known only from sections which give no information as to the shape of the wall, the most important of all the characters, and (2) that the calicles vary greatly on one and the same colony. In the latter case we have succeeded in finding out at least one of the laws of this variation. I refer to that according to which the calicles tend to revert to the primitive low-walled type on any edge of a colony which starts growing as a thin creeping layer.

The following are the most important morphological results of our inquiry with regard to the calicles. (*a*) We can define the primitive type of calicle. (*b*) The possible relations of its septal formula to the septal formula of the kindred genus *Porites* has been discovered. (*c*) Several types of calicle, all deducible from the primitive type, stand out clearly, and (*d*) a start has been made in correlating these types with definite methods of growth. For structural details, see the Introduction, pp. 18 *et seq.*

A. *The Primitive Type of Calicle.*

With low, thick wall, in the structure of which radial symmetry is still traceable, with the typical septal formula and pali, and with shallow fossa. The lateral budding of such calicles would necessarily result in explanate growths.

(*a*) With radial symmetry in the texture of the wall.

G. Great Barrier Reef 1. On the explanate portions.
G. North-West Australia 3.
G. Mauritius 1. On the explanate portions.

Doubtful:—

G. Sind 3. "Walls frequently reticular."
G. Paris Basin 1. Or under E.
Goniopora x g.

(*b*) With the wall texture melted down into a reticulum. The more plastic cœnenchyma thus produced is favourable for interstitial budding, and columns may result,—a

* I have, however, added lists of the very small and the very large calicled forms, although doubtful as to its utility.

process commonly seen in the genus *Montipora*, in which the cœnenchyma is more developed than in any other genus of Stony Corals. See Vol. III. of this Catalogue.

G. Solomon Islands 1. Slender columns or branches.
G. Solomon Islands 3. Rounded masses, but see observations of method of growth, p. 41.
G. Samoa 1.
G. Great Barrier Reef 12. Explanate, forming branching tufts at the edges.
G. Singapore 1.
G. Singapore 2.
G. Singapore 5.
G. Java Sea 2.
G. Sind 2. Walls sometimes flush.
G. Sind 4.
G. Vicenza 12.
G. Vicenza 13. With almost complete loss of radial symmetry in walls and septa.
G. Genoa 5. Walls reticular only in the angles.
G. Dax 2.
G. Somaliland 1.

Doubtful:—
G. China Sea 1.
G. Java Sea 4.
G. Sind 1. Walls thick only in the angles.
G. Sind 5.
G. Sind 7. Tertiaries reduced.
G. Persia 2.
G. Vicenza 2.
G. Oberburg 1. Or better under G.
G. Dax 3. Height of walls unknown.
G. Gironde 2. Height of walls unknown.

(*c*) Owing to crowding the walls are thin and sharp, and the calicles usually small and with some irregularity in the septal and palic formulæ.

G. Red Sea 5.
G. Persia 3.
G. Persia 4.
G. Vicenza 10. With 24 septa fusing irregularly.
G. Alessandria 3.
G. Vienna Basin 1.

Doubtful:—
G. Fiji Islands 1. Septa obscured.
G. Genoa 1.
G. Genoa 3. Or under G.
G. Paris Basin 3.
G. Vicenza 3. Or under G.

G. Vicenza 4.
G. Vicenza 5. Septa so wavy as to obscure the radial symmetry.
G. Vicenza 8.
G. Vicenza 9.
G. Turin 1.

(*d*) When the colony is very thin, the whole skeleton is reduced in size, and the walls are nearly flush with the surface.

a. The surface is composed of a mosaic of granules, which are the tips of the dwarfed vertical trabeculæ.

G. North-West Australia 2.
G. China Sea 2.
G. Maldives 1.
G. Paris Basin 2.

β. The surface is composed of horizontal flakes, the horizontal skeletal elements being developed at the expense of the vertical trabeculæ.

G. China Sea 3. A *Porites* showing the same specialisation comes from the same locality. Cf. *G. Paris Basin 6.*

(*e*) If the encrusting colony deepens, then the walls tend to rise in height and to be thinner and sharper, and the septal formula may be obscured by the greater depth of the calicles.

G. Great Barrier Reef 9.
G. Great Barrier Reef 11. Perhaps to B (*b*).
G. North-West Australia 4.
G. Verona 2.
G. Paris Basin 1.

Doubtful;—

G. Egypt 1.

The thickening of the stocks is associated with the formation of calicles with high walls as described under the next heading. But before leaving the primitive type of calicle and its variations, it should be re-stated that, whenever thin edges of colonies, no matter of what form of growth, start expanding, the calicles produced are always of the primitive type. But in every case these new calicles also show clear traces of the habit of the calicles typical of the particular colony to which they belong. Instances of this may be seen in the illustrations, cf. Pl. II. figs. 2 and 3, Pl. III. figs. 7 and 8, Pl. V. figs. 1 and 2, Pl. VI. figs. 1 and 2, Pl. VIII. figs. 1 and 2, etc.

B. *Calicles with High Walls.*

The increased height of the wall leads to the deepening of the fossa, and the sinking away of the intracalicular skeleton, which is variously modified and obscured.

(*a*) Walls thick.

a. Showing radial symmetry in their component elements.

G. Tonga Islands 1
G. Tonga Islands 2
G. Tonga Islands 3 } but tending towards D (p. 180).

G. Great Barrier Reef 2.
G. Great Barrier Reef 9. Placed also in A (*e*).
G. North-West Australia 5.
G. North-West Australia 6. In parts (see Pl. IV. figs. 4 and 5), also β in parts (Pl. IV. fig. 6).*
G. Philippines 4. On the thinner parts of stock, see also under β.*

Doubtful:—
G. New Guinea 1.
G. Great Barrier Reef 3. Tending towards D.

β. Walls reduced to a reticulum.
G. Great Barrier Reef 6.
G. Great Barrier Reef 7, specimens *a* and *c*.
G. North-West Australia 6. In parts, see also under α.*
G. Philippines 4. On the thicker parts of the stock, see also under α.*
G. Singapore 4.

(*b*) Walls thin.

α. Composed of single rows of stout fused trabeculæ, the tips of which cause the margins to be denticulate; from below the edges the septa slope very gradually into the depths of the calicle, so that both the pali and the columellar tangle, which in the primitive shallow calicle formed a flat floor, are obscured.
G. Loyalty Islands 1.
G. Great Barrier Reef 7, specimen *b*.
G. Great Barrier Reef 11. Perhaps also to A (*e*).
Goniopora xd.

β. The trabeculæ not conspicuous as such, and tending with the wall synapticulæ to form smooth lattice-works. The columellar tangle is conspicuous.
G. Java Sea 1.
Goniopora xa.
G. Maldives 4. Walls almost membranous.
G. Singapore 6.

Doubtful:—
G. Egypt 2.

γ. Walls smooth, like membrane, and perforated with oval pores, closely resembling the walls of *Alveopora*.†
G. New Guinea 2, *G. Great Barrier Reef 10* } Septa as spines, also like those of *Alveopora*.
G. Moluccas 1. Septa as fine points.

* These cases show how easily the radial and concentric symmetry of the wall-elements may break down.

† At the sides of all these colonies the calicles revert to the primitive type with thicker walls; but for this they would be indistinguishable from true *Alveoporæ*. Other forms with spinous septa, like those of *Alveopora*, are *G. Red Sea 2* and *Goniopora xc*. The septa of *G. Red Sea 4* are filamentous, but hardly like those of *Alveopora*.

G. Philippines 2. Septa as thin twisted threads.
G. Paris Basin 14. Walls membranous, but with very few perforations.
G. Coutances 1. Septa run out into long spines.
Goniopora xe. Or under δ.
Goniopora xc. With septa as sharp hair-like points.

δ. Walls with trabeculæ otherwise specialised.
G. Great Barrier Reef 4. The tips of the trabeculæ as stout granules.
G. Great Barrier Reef 8. As the highest parts of irregular septa.
G. North-West Australia 1.

Doubtful :—
G. Great Barrier Reef 5.
Goniopora xe.

C. Calicles like deep, neatly cylindrical punctures in the otherwise smooth surface, usually with septa obscured, and instead, 6 prominent paliform plates. Only found in globular and massive growths. The genus *Rhodaræa* of authors.

G. Solomon Islands 2.
G. Great Barrier Reef 2.
G. Great Barrier Reef 3.
G. Celebes 1.
G. Philippines 2.
G. China Sea 4.

*Doubtful :—
G. Australia a.
G. Great Barrier Reef 3.
G. Philippines 3. The small size renders the calicles funnel-shaped.

D. Calicles are deep, irregular openings in twisted bundles of vertical laminæ, the radial symmetry being more or less obscured. They are only found on the tops of colonies which show the expanding sheaf growth-form, see p. 26, and Diagram D, p. 24. The primitive type of calicle always appears on the sides.

G. Singapore 3.
G. Maldives 2.
G. Maldives 3.
G. Red Sea 1.
G. Red Sea 2. With spiny septa.
G. Red Sea 3.
G. Red Sea 4. Calicles highly specialised, and approaching B (*b*) γ or δ.
G. Red Sea 6.

Doubtful :—
G. Queen Charlotte Islands 1.

* This type of calicle is also seen in the coral referred to in the Appendix to the English *Gonioporæ*, p. 153.

G. Tonga Islands 3.
G. Great Barrier Reef 3.
G. Seychelles 1.

E. Calicles gaping, open, shallow, funnel-shaped; large reticular columellar tangle, with pali obscured. These were sometimes described as the characteristics of the genus *Litharæa*, see pp. 14 and 146.

G. Philippines 1.
G. China Sea 5. If this coral has explanate portions, the calicles on such parts would resemble those of *G. Great Barrier Reef 1.*
G. Ceylon 1.
G. Vicenza 11. Small, 2 mm.
G. Paris Basin 1. Or under A (*a*).
G. Paris Basin 4. Absence of pali excludes it from A (*a*).
G. Paris Basin 5.
G. Paris Basin 6.
G. Paris Basin 7.
G. Paris Basin 13. Calicles small.
G. Sussex 1.
G. Hampshire 1.
G. Crimea 1.
Goniopora x f.

Doubtful:—

G. New Ireland 1. Note the growth-form and the inability of the polyps to withdraw into the calicles.
G. India a.
G. Egypt 3.
G. Paris Basin 8.

F. Calicles without any raised walls, that is, the septal edges are flush with the surface, though not on explanate stocks, or at the sides of columns.

G. Java Sea 3.
G. Red Sea 4. Or under D.
G. Sind 2. Walls sometimes raised.
G. Vicenza 1. Judging from the orginal figure.
G. Vicenza 7. On the sides of the stems.
G. Vienna Basin 2. ? Worn down.
G. Vienna Basin 3. Calicles marked off by rows of coarse grains.
G. Koritzan 1.
G. Bilin 1.
G. Dax 1. ? On the sides of stems.
G. Paris Basin 11, *G. Paris Basin 12* } Also under G.

Doubtful:—

G. Persia 1. Cf. *G. Vienna Basin 2*, Observations, p. 123.
G. Oberburg 2.

G. Calicles greatly reduced in size, with septa reduced in number, sometimes apparently only 12, and thus simulating the calicles of *Porites*, but, inasmuch as the septa fuse irregularly near the walls, they do not show the septal formula typical of that genus.

G. Sind 6. ? With sharp-edged walls.
G. Vicenza 3. Or perhaps A (*c*).
G. Turin 2.
G. Turin 3.
G. Genoa 3. Or perhaps A (*c*).
G. Vienna Basin 4.
G. Oberburg 1. Or A (*c*).
G. Dax 4.
G. Gironde 1.
G. Paris Basin 11. Also under F.
G. Paris Basin 12. Also under F.
G. France a.

H. Calicles with walls and septa melted down to a reticulum composed of lamellæ or filaments, though not on the top surfaces of the expanding sheaf formation (cf. D).

G. Singapore 2. In the uppermost calicles.
G. Vicenza 5.
G. Vicenza 13.
G. Paris Basin 9. Radial symmetry traceable.
**G. Paris Basin 10.*
G. Coutances 2.
Goniopora xb.

I add supplementary divisions to show the distributions of the forms with very large and with very small calicles.

J. Calicles over 4 mm.

G. Solomon Islands 3. 4–5 mm. Recent.
G. North-West Australia 2, *G. North-West Australia 3*, *G. North-West Australia 4* } 5 mm. Recent.
G. Philippines 1. 4–5 mm. Recent.
G. China Sea 5. 3–6 mm. Recent.
G. Java Sea 2. 4–5 mm. Upper Miocene.
G. Ceylon 1. 4–5 mm. Recent.
G. Maldives 4. 6–7 mm. Recent.
G. Sind 1. Up to 6 mm. Upper Cretaceous or Eocene.
G. Sind 2. Up to 12·5 mm. Lower Eocene.
G. India a. 4–5 mm. Eocene.

* *G. Paris Basin 5* and *6* are melted down into a reticulum, but on a different principle, namely, by the proliferations of the septal synapticular outgrowths.

G. Red Sea 1. 3–5 mm. Recent.
G. Egypt 2. 5–7 mm. Lower Eocene.
G. Vicenza 6. 4·5–6 mm. Oligocene.
G. Genoa 4. Up to 7 mm. Upper Oligocene.
G. Dax 2. 5–6 mm. Miocene.
G. Gironde 2. 5 mm. Miocene.
G. Sussex 1. Occasional specimens. 5 mm. Middle Eocene.
G. Crimea. 5 mm. Lower Cretaceous.

K. Calicles under 2 mm.

G. North-West Australia 2. 1·5–2 mm. Recent.
G. Red Sea 4. 1·5 mm. Recent.
G. Vicenza 2. 1–2 mm. Middle Eocene.
G. Vicenza 3. 1·5–2 mm. Oligocene.
G. Vicenza 13. 1·75 mm. Oligocene?
G. Alessandria 3. 1·75–2 mm. Miocene.
G. Turin 2. 1·5 mm. Middle Miocene.
G. Turin 3. 1 mm. Middle Miocene.
G. Genoa 3. 1·5 mm. Upper Oligocene.
G. Genoa 5. Up to 2 mm. Upper Oligocene.
G. Vienna Basin 2. 1·5–2 mm. Miocene.
G. Vienna Basin 4. 1·2–1·5 mm. Miocene.
G. Dax 4. 1·2 mm. Oligocene.
G. Gironde 1. 1·5 mm. Oligocene.
G. Paris Basin 3. 1·5 mm. Upper Eocene.
G. Paris Basin 11. 1·5–2 mm. Upper Eocene.
G. France a. 1 mm. Middle Miocene?

Table V.—THE SEPTAL FORMULA.

The septal formula which characterised the primitive calicle, probably as an inheritance from Eupsammiid ancestors, is shown in the Diagram A, p. 21. This persists in many forms; in others it is only traceable; from others again it has entirely disappeared; lastly, in many cases we can have no information because the descriptions were made at a time when the formula, which was only discovered during the progress of the present volume, was quite unknown.

As a rule we may say that the septal formula can only persist in shallow calicles. In the deep calicles it is naturally obscured by the fact that the growing walls carry up the peripheral edges of the septa, while their central portions sink into the depths of the fossa. It is, however, occasionally seen in deep-calicled forms, e.g. in *G. Java Sea 1* and *G. Maldives 4*.

A. *Forms in which the Typical Formula persists.*

(*a*) Easily seen.

G. Great Barrier Reef 1.
G. North-West Australia 2.
G. North-West Australia 3. With occasionally parts of a fourth cycle.
G. North-West Australia 4. Slightly obscured by the large columellar tangle.
G. Philippines 1.
G. China Sea 2.
G. China Sea 5.
G. Java Sea 1.
G. Java Sea 2.
G. Singapore 2.
G. Ceylon 1.
G. Maldives 1.
G. Maldives 4.
G. Mauritius 1.
G. Sind 1.
G. Sind 2. No trace of the fourth cycle in spite of immense size of calicle.
G. Persia 3.
G. Persia 4.
G. Egypt 3.
G. Vicenza 7.
G. Genoa 3.
G. Genoa 5.
G. Dax 3.
G. Gironde 2.
G. Paris Basin 4.
G. Sussex 1.
G. Hampshire 1.

(*b*) Probably complete, but obscured by the great size of the columellar tangle.

G. Java Sea 4.
G. India a.
G. Egypt 1.
G. Egypt 2. Sometimes part of fourth cycle.
G. Vicenza 6.
G. Dax 2.
G. Paris Basin 5.
G. Paris Basin 6.
G. Paris Basin 7.
G. Paris Basin 8.
G. Crimea 1.

B. *Shallow-Calicled Forms in which the Septal Formula is seen only in Traces.*

G. Solomon Islands 1.
G. Solomon Islands 3. Formula obscured by irregularity.
G. Samoa 1.
G. Great Barrier Reef 6.
G. North-West Australia 1.
G. Moluccas 1.
G. Philippines 3.
G. China Sea 3.
G. Java Sea 3.
G. Singapore 1.
G. Singapore 4.
G. Sind 3.
G. Sind 4.
G. Vicenza 3.
G. Vicenza 5.
G. Vicenza 8.
G. Vicenza 12.
G. Vicenza 13.
G. Verona 2.
G. Alessandria 3.
G. Oberburg 2.
G. Koritzan 1.
G. Bilin 1.
G. Dax 4.
G. Paris Basin 1.
G. Paris Basin 11.
G. Paris Basin 12.
G. Somaliland 1.

Further, in all those cases given under G. in Table IV., in which the fusions of the septa

take place so near the wall as to appear part of the wall reticulum, the number of the septa is thereby reduced to 12; this causes a superficial resemblance to the calicles of *Porites*, but traces of the typical formula may be seen in the very fact of this fusion.

C. *Deep-Calicled Forms in which Traces of the Formula can still be seen.*

In forms with neat round calicles looking as if punctured into the smooth surface, a conspicuous rosette of paliform plates appears to take the place of the septa; this six-rayed rosette is clearly a part of the typical septal formula, the rest of which may sometimes be seen deep down in the calicle, e.g. *G. China Sea 4.* This list need not be repeated, it is given in Table IV., C.

In other deep-calicled forms the formula, though quite lost in the calicles of the central regions, may (*a*) reappear in the lateral calicles, or (*b*) may be seen in the fact that if the calicle is looked at from above, or in section, the tertiaries often bend round towards the secondaries.

(*a*)..... *G. North-West Australia 6.*
G. Philippines 4.
G. Maldives 2. Obscured by parts of the fourth cycle.
G. Red Sea 1.
G. Red Sea 3. In traces.
G. Red Sea 6. In very slight traces.

(*b*) ..... *G. Tonga Islands 1.*
G. Vicenza 11. In section.
G. Genoa 4.

We find, therefore, that there are about 38 forms in which the formula is known to be, or can be assumed to be, typical, and close upon 60 forms in which it is altered and obscured, though unmistakable traces of it can still be made out. These numbers would probably be increased if the early "species" could be re-examined.

SUMMARY OF RESULTS.

THE present volume has dealt with a single genus as exhaustively as the material * and the opportunities of studying it have allowed.

The result has been a considerable advance. The essential characters of the genus have been discovered, and the genera *Rhodaræa*, *Tichopora* and *Litharæa* have been shown to belong to it.

It is now possible to trace the genus back through time, at least to the Cretaceous period, and to follow some of the shiftings of its distribution.

The relationship of the genus to *Porites*, which, with *Goniopora*, constitutes the family Poritidæ, has been provisionally defined, and the view that the two families, Poritidæ and Madreporidæ, had a common origin from the simpler Eupsammiids, which was suggested by the system of Milne-Edwards and Haime, has been rendered more probable.

Some 150 modifications on what, from a comparison of the existing forms, we gather to have been the primitive type, are described, and most of those, the original specimens of which are in the National Museum, have been illustrated so as to show the two chief structural characters, the method of growth and the structure of the calicle. The possibilities of variation in each of these two characters, taken alone, are very great, but when there is also colony formation the variability becomes extremely complex. It is one of the more important results of this treatise to have shown that there exists some close interdependence between calicle-forms and growth-forms. Indeed some of the rules of this interdependence have been discovered. For instance, we now know why the calicles at the sides of stocks are always shallower than those in the centre: it is not, as many suggested, a question of age, but is due to this interdependence between calicle-form and growth-form. The shallower calicles are, in fact, those produced by the thin expanding or creeping edges of a colony, and hence resemble those typical of explanate stocks.

* The work is primarily a descriptive catalogue of the representatives of the genus, both recent and fossil, which are preserved in the British Museum of Natural History. In addition, specimens from Cambridge, from Paris, from Leyden and from Rome have been examined at various times. It is to be regretted that all the available material stored in the Museums of Europe could not be brought together for close comparative study. Had that been possible, the results might have been different.

But this interdependence is also a cause of much confusion, for one of its consequences is that slight accidental changes in the growth-form are sufficient to change the type of the calicle. This being so it is evident that the foundation which our knowledge affords is too shifting for the establishment of stable groups, and the question even as to the existence of such groups must remain unanswered. Moreover, if they exist, it is hardly to be expected that 150 forms alone, collected casually one from this spot and one from that, not only from the whole area, but from all the different strata of that area where and in which the genus is found, could yield us a survey wide enough to enable us to distinguish them. The material is only just sufficient to enable us to answer the morphological inquiries without which useful systematic work is impossible. It is not even sufficient to show us more than small fragments of the range of actual variation. Series, therefore, could hardly be expected. We have, however, discovered certain types or repetitions of structure which may be profitably arranged into morphological groups, though these groups cannot be called "species." *

The only specimens showing unmistakable genetic affinities are those which have been gathered from the same spot, and are obviously daughter colonies of one and the same parent.† The largest area over which such a genetic group is as yet known to spread is that of the Maldive Islands. One simple form of Gonioporan colony, with calicles which are those characteristic of its type of growth, ‡ has been discovered by Mr. Gardiner occurring at considerable depths round at least four of these islands. The fact, however, that we here have a genetic group seems to me to be of less real importance than the evidence which the specimens themselves yield that they all alike developed on a soft, muddy bottom. This determined the growth-form, and the growth-form is, as we have seen, largely responsible for the type of the calicles.

It is impossible, therefore, to argue that because we have a stable genetic group extending over a given area, similar groups can be assumed for every single specimen that comes to hand. The assumption may be true or it may be false. Nothing is gained by assuming either one or the other. We must discover the facts.

My own opinion, given with diffidence, is that the Stony Corals are still too elementary in their organisation to be able to acquire any but transient stability, § if such an expression can be admitted. I am disposed to think that they respond very quickly to the environment. Where cases of two distinct forms of the same genus are found growing side by side, and thus obviously in the same environment, one of them is probably a new arrival; the differences between them will sooner or later disappear. If it be not so, I do not see how we are to

* Professor Döderlein, in his monograph of the genus *Fungia* (see footnote p. 191), which consists of single calicles not complicated by colony formation, has discovered structural groups which he calls species. Had the forms so grouped united into colonies, the variability seen in them would have been immediately intensified and the nebulousness of the groups greatly increased. The strength of Professor Döderlein's groups rests largely upon the fact that he had at his disposal an immense collection of these simple corals, which are easily packed and transported.

† This Catalogue, Vol. II. p. 30. ‡ Cf. *G. Maldives 4*, p. 59. § Cf. *G. Sussex 1*, p. 147.

account for the fact that we have, in the National Collection, corals even of different genera growing side by side, so like one another, not only in habit but even in deeper skeletal texture, that only an expert can tell the one from the other. In two instances only * is it at present known that they are from the same localities. We have other instances of close resemblance between specimens of different genera,† and I fully expect, as these researches continue, to discover that for these also the environments were similar.

The chief results, then, are practically all that could be expected from the relatively small amount of the material. They are almost exclusively morphological, phylogenetic and biological. The systematic arrangement of the forms in the order of their evolution cannot yet be attempted.

* See p. 72. † See p. 180.

CONCLUDING REMARKS ON THE ADVANTAGES OF USING GEOGRAPHICAL SYMBOLS.

With a List of the Latinised Equivalents of those here Employed.

I not only most willingly comply with the request of the Director to deal with this subject a little more fully than I have done in the Introduction, but I am grateful to him for giving me the opportunity.

It must, of course, be at once admitted that names like those usually employed to indicate species might have been used instead of geographical symbols. But the objections to names seem to be many and serious.

A "specific name," by long usage and almost universal agreement, implies a true genetic group, and my experience has been that no explanation as to the meaning assigned to the use of the name can change this. When we are not dealing with species but with forms, from the ultimate grouping of which species may perhaps be discovered, the work is confusing if the method of designation for the forms is that used for the species. Some special method is needed for this preliminary analytical stage of the work. Only when the natural groups have been discovered should names be used.

The use of some special symbol for this preliminary study becomes obvious if we picture to ourselves what must happen as soon as true genetic groups or species can be compounded from series of known forms. One of the names will be retained as the name of the species, others as the names of varieties, while the rest will have to be discarded as mere synonyms. Working symbols have this advantage over ordinary specific names, that they can be legitimately discarded if we so desire. But it seems to me that, while we would certainly desire to discard a wearisome and perfectly unintelligible list of synonymous *names*, there would be no desire to discard synonymies composed of geographical symbols, for they would give at a glance the geographical distributions of the species and of its several varieties.

The attempt here made to record forms is being made in other groups besides corals, but so far only in such groups as have already been divided into species. The process involves the addition to the accepted specific name of one or more qualifying names, one of which invariably indicates the locality. In this way the old binominal designation of Linnæus is forming the basis for a multinominal system of recording the varying forms which we now find

embraced by the species. This system cannot be adopted in the corals for the simple reasons that only a very small proportion of the corals have yet received any names at all, and only a few of those which have been named can now be identified. The process is, therefore, not one of designating the forms which make up established species, but of recording forms which may some day be grouped into species. We who are working with corals, then, are in a position favourable to the adoption of a new and more straightforward method of dealing with the species problem. In reality we are still in the throes of sorting out genera, and all the most solid work of the past is chiefly valuable in this respect. Even this stage is far from complete. The task, therefore, is complicated, and the new method should be technically simple, practical, and efficient.

The question thus arises, whether names or symbols best fulfil these conditions. Names, when there are only a few of them, may be easier to remember, but long lists are a dead weight upon the work. While there may ultimately prove to be but few *groups* or *species* requiring names, the number of *forms* to be designated is bound to be very large. For example, the analytical tables which now give at a glance the geographical distribution of the different structural divisions, would have been far less useful if meaningless names had been given to the forms. It seems to me that we have no other alternative than that between "trivial" names and symbols. It is not possible to invent a long list of short names, each one of which shall convey useful information, except on some fixed plan, and that, sooner or later, means the construction of symbols or of symbolic names.

Inasmuch, however, as I have been warned again and again that there are rigid formalists who will not perceive that there may be groups of animal forms whose method of growth and propagation is such as to require a different treatment from that used for those possessing powers of locomotion,* or that the stage of our knowledge of a group may be so elementary that it is more scientific to study the group first and discover the species than to make species first and then study the group, it is evidently necessary to compromise. I am told that some such formalist may believe that he is doing zoology a service by naming, that is, "making species" of all the forms here recorded by geographical symbols. Two years ago I should have found this hard to believe. But recent experience compels me to respect the warning and to give a list of Latin equivalents for my geographical symbols. I put them in this form, first, in order to make them easier to remember than would be possible if we had two quite distinct and separate lists—that is a list of symbols and a list of names relating to the same things; secondly, in order to show in the character of the formula that I wish to distinguish these *names of forms* from the *names of species*; and lastly, in order that, if and when groupings of the forms can be profitably made and receive ordinary specific names, these form-names, in constituting the list of synonyms, will show at a glance the geographical distribution of the species.

* Cf. introduction to Prof. Döderlein's 'Die Korallengattung Fungia,' Abh. Senckenb. Nat. Ges., xxvii. (1902) pp. 5, 6.

The proposed Latinised equivalents for the geographical symbols by which the known forms of *Goniopora* are here designated now follow.

[N.B.—In those cases in which the forms have been assumed by previous writers to represent separate and distinct *species*, the name of such species is given in brackets.]

G. New Guinea 1 = *G. Nova-guineensis prima* (*G. pedunculata* Quoy and Gaimard).
G. New Guinea 2 = *G. Nova-guineensis secunda.*
G. New Ireland 1 = *G. Nova-hibernica prima.*
G. Solomon Islands 1 = *G. Salomonis prima.*
G. Solomon Islands 2 = *G. Salomonis secunda.*
G. Solomon Islands 3 = *G. Salomonis tertia.*
G. Queen Charlotte Islands 1 = *G. Carlottæ prima* (*G. viridis* Quoy and Gaimard).
G. Loyalty Islands 1 = *G. Fidelium prima.*
G. Fiji Islands 1 = *G. Fidjiensis prima* (*G. columna* Dana).
G. Tonga Islands 1 = *G. Tongaensis prima.*
G. Tonga Islands 2 = *G. Tongaensis secunda.*
G. Tonga Islands 3 = *G. Tongaensis tertia* (? *G. parvistella* Ortmann).
G. Samoa 1 = *G. Samoensis prima* (? *G. parvistella* Ortmann).
G. Great Barrier Reef 1 = *G. Queenslandiæ prima.*
G. Great Barrier Reef 2 = *G. Queenslandiæ secunda.*
G. Great Barrier Reef 3 = *G. Queenslandiæ tertia.*
G. Great Barrier Reef 4 = *G. Queenslandiæ quarta.*
G. Great Barrier Reef 5 = *G. Queenslandiæ quinta.*
G. Great Barrier Reef 6 = *G. Queenslandiæ sexta.*
G. Great Barrier Reef 7 = *G. Queenslandiæ septima.*
G. Great Barrier Reef 8 = *G. Queenslandiæ octava.*
G. Great Barrier Reef 9 = *G. Queenslandiæ nona.*
G. Great Barrier Reef 10 = *G. Queenslandiæ decima.*
G. Great Barrier Reef 11 = *G. Queenslandiæ undecima.*
G. Great Barrier Reef 12 = *G. Queenslandiæ duodecima* (*G. fruticosa* Saville-Kent).
G. North-West Australia 1 = *G. Australiæ occidentalis prima.*
G. North-West Australia 2 = *G. Australiæ occidentalis secunda.*
G. North-West Australia 3 = *G. Australiæ occidentalis tertia.*
G. North-West Australia 4 = *G. Australiæ occidentalis quarta.*
G. North-West Australia 5 = *G. Australiæ occidentalis quinta.*
G. North-West Australia 6 = *G. Australiæ occidentalis sexta.*
G. Australia a = *G. Australiæ* (*G. calycularis* Lamarck).
G. Moluccas 1 = *G. Moluccensis prima* (*G. tenuidens* Quelch).
G. Celebes 1 = *G. Celebesensis prima.*
G. Philippines 1 = *G. Philippina prima* (*G. tenella* Quelch).
G. Philippines 2 = *G. Philippina secunda.*
G. Philippines 3 = *G. Philippina tertia.*
G. Philippines 4 = *G. Philippina quarta.*
G. China Sea 1 = *G. Sinensis prima* (*G. lagreneei* Edwards and Haime).
G. China Sea 2 = *G. Sinensis secunda.*
G. China Sea 3 = *G. Sinensis tertia.*

G. China Sea 4 = *G. Sinensis quarta.*
G. China Sea 5 = *G. Sinensis quinta.*
G. Java Sea 1 = *G. Javanica prima.*
G. Java Sea 2 = *G. Javanica secunda* (*G. affinis* Reuss).
G. Java Sea 3 = *G. Javanica tertia* (*G. incrassata* Reuss).
G. Java Sea 4 = *G. Javanica quarta* (*G. astræoides* Martin).
G. Singapore 1 = *G. Singaporensis prima.*
G. Singapore 2 = *G. Singaporensis secunda* (*? G. Malaccensis* Brüggemann).
G. Singapore 3 = *G. Singaporensis tertia* (*? G. Malaccensis* Brüggemann).
G. Singapore 4 = *G. Singaporensis quarta.*
G. Singapore 5 = *G. Singaporensis quinta.*
G. Singapore 6 = *G. Singaporensis sexta.*
G. Ceylon 1 = *G. Ceylonica prima.*
G. Maldives 1 = *G. Maldivium prima.*
G. Maldives 2 = *G. Maldivium secunda.*
G. Maldives 3 = *G. Maldivium tertia.*
G. Maldives 4 = *G. Maldivium quarta.*
G. Mauritius 1 = *G. Mauritiensis prima.*
G. Seychelles 1 = *G. Seychellensis prima.*
G. Sind 1 = *G. Sindica prima* (*G. epitheeata* Duncan).
G. Sind 2 = *G. Sindica secunda* (*G. grandis* Duncan).
G. Sind 3 = *G. Sindica tertia* (*G. superposita* Duncan).
G. Sind 4 = *G. Sindica quarta* (*G. Indica* Duncan).
G. Sind 5 = *G. Sindica quinta* (*G. nodulosa* Duncan).
G. Sind 6 = *G. Sindica sexta.*
G. Sind 7 = *G. Sindica septima.*
G. India a = *G. Indica incognita.*
G. Persia 1 = *G. Persica prima.*
G. Persia 2 = *G. Persica secunda.*
G. Persia 3 = *G. Persica tertia.*
G. Persia 4 = *G. Persica quarta.*
G. Red Sea 1 = *G. Erythræa prima* (*G. planulata* Ehrenberg).
G. Red Sea 2 = *G. Erythræa secunda.*
G. Red Sea 3 = *G. Erythræa tertia.*
G. Red Sea 4 = *G. Erythræa quarta* (*? G. gracilis* Edwards and Haime).
G. Red Sea 5 = *G. Erythræa quinta* (*G. lichen* Klunzinger).
G. Red Sea 6 = *G. Erythræa sexta.*
G. Egypt 1 = *G. Ægyptiaca prima.*
G. Egypt 2 = *G. Ægyptiaca secunda.*
G. Egypt 3 = *G. Ægyptiaca tertia.*
G. Vicenza 1 = *G. Vicentina prima* (*G. ramosa* Catullo).
G. Vicenza 2 = *G. Vicentina secunda* (*G. pellegrinii* D'Archiardi).
G. Vicenza 3 = *G. Vicentina tertia* (*G. minuta* Reuss).
G. Vicenza 4 = *G. Vicentina quarta* (*G. nummulitica* Reuss).
G. Vicenza 5 = *G. Vicentina quinta* (*G. micrantha* Reuss).
G. Vicenza 6 = *G. Vicentina sexta* (*G. rudis* Reuss).

G. Vicenza 7 = *G. Vicentina septima.*
G. Vicenza 8 = *G. Vicentina octava.*
G. Vicenza 9 = *G. Vicentina nona.*
G. Vicenza 10 = *G. Vicentina decima* (*G. dissita* Angelis).
G. Vicenza 11 = *G. Vicentina undecima* (*G. eximia* Angelis).
G. Vicenza 12 = *G. Vicentina duodecima.*
G. Vicenza 13 = *G. Vicentina tertia decima.*
G. Verona 1 = *G. Veronica prima.*
G. Verona 2 = *G. Veronica secunda.*
G. Alessandria 1 = *G. Alessandrina prima* (*G. collegniana* Michelin).
G. Alessandria 2 = *G. Alessandrina secunda* (*G. diversiformis* Sismonda).
G. Alessandria 3 = *G. Alessandrina tertia.*
G. Turin 1 = *G. Taurinina prima.*
G. Turin 2 = *G. Taurinina secunda.*
G. Turin 3 = *G. Taurinina tertia.*
G. Genoa 1 = *G. Genuarum prima.*
G. Genoa 2 = *G. Genuarum secunda.*
G. Genoa 3 = *G. Genuarum tertia* (*G. michelotti* Angelis).
G. Genoa 4 = *G. Genuarum quarta* (*G. ambigua* Angelis).
G. Genoa 5 = *G. Genuarum quinta.*
G. Vienna Basin 1 = *G. Vindobonarum prima.*
G. Vienna Basin 2 = *G. Vindobonarum secunda* (*G. leiophylla* Reuss).
G. Vienna Basin 3 = *G. Vindobonarum tertia* (*G. leptoclada* Reuss).
G. Vienna Basin 4 = *G. Vindobonarum quarta.*
G. Oberburg 1 = *G. Oberburgensis prima.*
G. Oberburg 2 = *G. Oberburgensis secunda* (*G. lobata* Reuss).
G. Koritzan 1 = *G. Koritzana prima* (*G. michelini* Reuss).
G. Koritzan 2 = *G. Koritzana secunda.*
G. Bilin 1 = *G. Bilinensis prima* (*G. textilis* Posta).
G. Dax 1 = *G. Daxi prima.*
G. Dax 2 = *G. Daxi secunda* (*G. raulini* Edwards and Haime).
G. Dax 3 = *G. Daxi tertia.*
G. Dax 4 = *G. Daxi quarta.*
G. Gironde 1 = *G. Girundiensis prima.*
G. Gironde 2 = *G. Girundiensis secunda.*
G. Paris Basin 1 = *G. Parisiorum prima* (*G. crispa* Michelin).
G. Paris Basin 2 = *G. Parisiorum secunda* (*G. bellula* Michelin).
G. Paris Basin 3 = *G. Parisiorum tertia* (*G. ameliana* Michelin [? Defrance]).
G. Paris Basin 4 = *G. Parisiorum quarta.*
G. Paris Basin 5 = *G. Parisiorum quinta.*
G. Paris Basin 6 = *G. Parisiorum sexta.*
G. Paris Basin 7 = *G. Parisiorum septima.*
G. Paris Basin 8 = *G. Parisiorum octava.*
G. Paris Basin 9 = *G. Parisiorum nona* (? *G. heberti* Edwards and Haime).
G. Paris Basin 10 = *G. Parisiorum decima.*
G. Paris Basin 11 = *G. Parisiorum undecima.*

G. Paris Basin 12	= *G. Parisiorum duodecima.*
G. Paris Basin 13	= *G. Parisiorum tertia decima.*
G. Paris Basin 14	= *G. Parisiorum quarta decima.*
G. Coutances 1	= *G. Constantiarum prima* (? *G. desnoyersi* Edwards and Haime).
G. Coutances 2	= *G. Constantiarum secunda.*
G. France a	= *G. Galliæ.*
G. Sussex 1	= *G. Cicestriarum prima* (*G. websteri* Bowerbank).
G. Hampshire 1	= *G. Wintoniorum prima* (*G. brockenhursti* Duncan).
G. Crimea 1	= *G. Taurica prima* (*G. taurica* Eichwald).
G. Somaliland 1	= *G. Somaliensis prima* (*G. parkinsoni* Gregory).
G. Antigua 1	= *G. Antiguensis prima* (*G. irregularis* Duncan).

INDEX OF GENERIC AND SPECIFIC NAMES.

[Figures in black type refer to pages on which the descriptions will be found.]

EXPLANATION OF THE PLATES.

PLATES I.–X*b*.—Collotyped reproductions of magnified photographs taken by Mr. Murray (of Messrs. Morgan and Kidd), five times natural size throughout, except Pl. VIII., figs. 4 and 5.

PLATES XI.–XIV.—Lithographic reproductions from drawings of the specimens, by Mr. A. T. Hollick, to illustrate the growth-form alone, without regard to relative sizes.

PLATE I.

FIG.
1. Lateral calicles of *G. Solomon Islands 1*; for growth-form, see Pl. XI. fig. 1.
2. Upper calicles of *G. Solomon Islands 2*; „ „ fig. 2.
3. „ „ *G. Solomon Islands 3*; „ „ fig. 3.
4. „ „ *G. Loyalty Islands 1*; „ „ fig. 4.
5. „ „ *G. Tonga Islands 1*; „ „ fig. 5.
6. „ „ *G. Tonga Islands 2*; „ „ fig. 6.
7. „ „ *G. Tonga Islands 3*; „ „ fig. 7.
8. Lateral calicles near the top of *G. Samoa 1*; „ „ fig. 8.
9. Calicles from detached basal fragment of the same.

PLATE II.

1. From explanate portion of *G. Great Barrier Reef 1*; for growth-form, see Pl. XI. fig. 9.
2. From the top of *G. Great Barrier Reef 2*; for growth-form see Pl. XI. fig. 10.
3. Lateral calicles of the same.
4. From the side of *G. Great Barrier Reef 3*; for growth-form, see Pl. XI. fig. 11.
5. Median calicles of *G. Great Barrier Reef 4*, a fragment.
6. Lateral calicles of *G. Great Barrier Reef 5*, a fragment.
7. From the top of *G. Great Barrier Reef 6*; for growth-form, see Pl. XI. fig. 12.
8. Lateral calicles of the same.
9. From the top of *G. Great Barrier Reef 7*, specimen *a*; for growth-form of specimen *b*, see Pl. XII. fig. 1; other details of the same coral are given on the next plate (figs. 1 and 2).

PLATE III.

1. New calicles on specimen *b* of *G. Great Barrier Reef 7*, see Text (p. 54) and Pl. XII. fig. 1.
2. Section of specimen *a*, showing perforate septa and tabulæ.
3. Near the edge of the top of *G. Great Barrier Reef 8*; for growth-form, see Pl. XI. fig. 13.
4. From the top of *G. Great Barrier Reef 9*.
5. Median calicles of *G. Great Barrier Reef 10*; for growth-form, see Pl. XII. fig. 2.

PLATE III.—*continued.*

FIG.
6. Edge, showing the epitheca, of *G. Great Barrier Reef 11*; for growth-form, see Pl. XI. fig. 14.
7 (accidentally inverted). From the side of a stem of *G. Great Barrier Reef 12*; for reference to figures of growth-form, see Table I. p. 162, or Text, p. 58.
8. From an explanate portion of another stock of the same.
9. From the top of *G. North-West Australia 1.*

PLATE IV.

1. From the surface of *G. North-West Australia 2*; for growth-form, see Pl. XI. fig. 15.
2. „ „ *G. North-West Australia 3*; „ „ Pl. XII. fig. 3.
3. From upper slope of *G. North-West Australia 4*; „ „ Pl. XII. fig. 4.
4. From specimen *b* of *G. North-West Australia 6*; „ „ Pl. XII. fig. 6.
5 and 6. Different kinds of calicles on specimen *a* of the same; see also Pl. XII. fig. 5.
7. Median calicles of *G. Moluccas 1*; for reference to figure of the growth-form, see Table I. p. 163.
8. From the upper surface of *G. Celebes 1*; for growth-form, see Pl. XII. fig. 7, and for abnormal calicles, see Pl. IX. fig. 3.
9. From side of *G. Philippines 1*; for reference to figure of the growth-form, see Table I. p. 163.

PLATE V.

1. Upper calicles of *G. Philippines 2.*
2. Lateral calicles of the same.
3. Surface calicles of *G. Philippines 4.*
4. Surface calicles of *G. China Sea 2*; for growth-form, see Pl. XII. fig. 8.
5. Surface calicles (near the edge) of *G. China Sea 3*; for growth-form, see Pl. XII. figs. 9*a*, 9*b*.
6. From the top of *G. China Sea 4*; for growth-form, see Pl. XII. fig. 10.
7. Tip of a branch of *G. China Sea 5*; for growth-form, see Pl. XII. fig. 11, right.
8. Under surface near lower edge of same; for growth-form, see Pl. XII. fig. 11, left.
9. From side of a branch of *G. Singapore 1*; for growth-form, see Pl. XII. fig. 12.

PLATE VI.

1. Near the top of *G. Singapore 2*; for growth-form, see Pl. XII. fig. 13.
2. From the side lower down of the same.
3. From the top surface of *G. Singapore 3*; for growth-form, see Pl. XIII. fig. 1.
4. Lateral calicles of the same.
5. Uppermost calicles of *G. Singapore 4**; for growth-form of British Museum specimen, see Pl. XIII. fig. 2.
6. Lateral calicles of the same.*
7. From the top of *G. Singapore 5*; for growth-form, see Pl. XIII. fig. 3.
8. Lateral calicles of the same.
9. From the side of *G. Ceylon 1*; for growth-form, see Pl. XIII. fig. 5.

* From the specimen in the Cambridge Museum.

PLATE VII.

FIG.

1. Surface, with slightly raised walls, of *G. Maldives 1*; for growth-form, see Pl. XIII. fig. 6.
2. From the top surface of *G. Maldives 2*; for growth-form, see Pl. XIII. fig. 7.
3. Lateral calicles of the same.
4. From the top surface of *G. Maldives 3*; for growth-form, see Pl. XIII. fig. 8.
5. Some lateral calicles of the same.
6. From the side of *G. Maldives 4* (Suvadiva); for growth-form, see Pl. XIII. fig. 9.
7. From extreme tip of column of *G. Mauritius 1*; for growth-form, see Pl. XIII. fig. 10.
8. From the explanate portion of the same.
9. From top surface of *G. Red Sea 4*; for growth-form, see Pl. XIII. fig. 11.

PLATE VIII.

1. From the top of *G. Red Sea 1*; for growth-form, see Pl. XIII. fig. 12, and reference in Table I. p. 164.
2. Lateral calicles of the same.
3. From the lateral slope of *G. Red Sea 6*; for growth-form, see Pl. XIII. fig. 13.
4. *Goniopora x a*, about natural size.
5. *Goniopora x d*, about natural size.
6. From the side of *Goniopora x f*; for growth-form, see Pl. XIV. fig. 4.
7. From near the top of *Goniopora x e*; for growth-form, see Pl. XIV. fig. 3.
8. From surface of *Goniopora x b*; for growth-form, see Pl. XIV. fig. 1.

PLATE IX.

1. From the top of *Goniopora x c*; for growth-form, see Pl. XIV. fig. 2.
2. Lateral calicles of the same.
3. Abnormal calicles on dead portion of *G. Celebes 1*; cf. Text, pp. 67 and 155.
4. From worn pebble of *Goniopora Dax 3*.
5. Part of (?) original surface of *Goniopora Gironde 1*; for form of specimen, see Pl. XIV. fig. 8.
6. Upper surface of worn pebble of *Goniopora Gironde 2*; for form of specimen, see Pl. XIV. fig. 7.
7. A specimen of *Campanile giganteum*, showing two colonies of Michelin's "*Astræa*" *bellula* (= *Goniopora Paris Basin 2*; for calicles, see next Plate, fig. 1), slightly over half natural size.

PLATE X.

1. From the uppermost colony of *Goniopora Paris Basin 2*, shown in Plate IX. fig. 7.
2. Specimen *c* } of *Goniopora Paris Basin 4*, showing three stages in the proliferation of the
3. Specimen *a* } synapticular formations of the septa. In fig. 3 a tabula takes the place of
4. Specimen *b* } a columellar tangle.
5. From upper surface of *Goniopora Paris Basin 5*; for form of specimen, see Pl. XIV. fig. 9.
6. From probably worn surface of *Goniopora Paris Basin 6*; for form of specimen, see Pl. XIV. fig. 10.
7. From a fragment of *Goniopora Paris Basin 7*.
8. From upper surface of encrusting specimen of *Goniopora Paris Basin 8*.
9. From top of *Goniopora Paris Basin 9*; for growth-form, see Pl. XIV. fig. 11.

PLATE X[a].

FIG.
1. Worn surface of specimen *a*, *Goniopora Paris Basin 10*; showing tabulæ.
2. Worn surface of specimen *b*, *Goniopora Paris Basin 10*, with smaller calicles; showing tabulæ.
3. Upper lateral surface of *Goniopora Paris Basin 11*; for growth-form, see Pl. XIV. fig. 12.
4. From a small fragment, *Goniopora Paris Basin 12*.
5 and 6. From two opposite sides of specimen *a* of *Goniopora Paris Basin 14*; for growth-form, see Pl. XIV. fig. 14.
7. From top of *Goniopora Paris Basin 13*; for form of specimen, see Pl. XIV. fig. 13.
8. Top (?) view of specimen *b* of *Goniopora Paris Basin 14*; see Text, p. 143.

PLATE X[b].

1. Calicles of *Goniopora Coutances 1*; for growth-form, see Pl. XIV. fig. 16, and description, p. 143.
2. Calicles of *Goniopora Coutances 2*.
3. Worn surface of *Goniopora France a*.
4–7. Calicles of 4 specimens of *Goniopora Sussex 1*:—
   4. From top of nodule 2·5 × 2 cm., with encrusting edges. No. 2 in this Catalogue, p. 149.
   5. From top of an oval nodule 4 × 3 cm. on a small pebble 3 × 2 cm. No. 29 in this Catalogue, p. 152.
   6. From top of a specimen encrusting a shell. No. 3 in this Catalogue, p. 149.
   7. From top of a (?) worn fragment of a large stock. No. 30 in this Catalogue, p. 152.

DESCRIPTION OF THE LITHOGRAPHIC PLATES.

With approximate magnifications.

PLATE XI.

FIG.
1. Growth-form, × $\frac{1}{3}$, of *G. Solomon Islands 1*; for calicles from side, see Pl. I. fig. 1.
2. „ × $\frac{1}{3}$, of *G. Solomon Islands 2*; for calicles from upper surface, see Pl. I. fig. 2.
3. „ × $\frac{1}{2}$, of *G. Solomon Islands 3*; „ „ „ fig. 3.
4. „ × $\frac{3}{8}$, of *G. Loyalty Islands 1*; „ „ „ fig. 4.
5. „ × $\frac{3}{8}$, of *G. Tonga Islands 1*; „ „ „ fig. 5.
6. „ × $\frac{3}{10}$, of *G. Tonga Islands 2*; „ „ „ fig. 6.
7. „ × $\frac{1}{3}$, of *G. Tonga Islands 3*; „ „ „ fig. 7.
8. „ × $\frac{1}{3}$, of *G. Samoa 1*; for calicles from near top and base, see Pl. I. figs. 8 and 9.
9. „ × $\frac{1}{2}$, of *G. Great Barrier Reef 1*; for calicles on explanate surface, see Pl. II. fig. 1.

PLATE XI.—*continued.*

FIG.

10. Growth-form, × ⅓, of *G. Great Barrier Reef 2*; for calicles on top and sides, see Pl. II. figs. 2 and 3.
11. „ × ½, of *G. Great Barrier Reef 3*; for calicles from the side, see Pl. II. fig. 4.
12. „ × ½, of *G. Great Barrier Reef 6*; for calicles on the top and sides, see Pl. II. figs. 7 and 8.
13. „ × ⅜, of *G. Great Barrier Reef 8*; for calicles on the top, see Pl. III. fig. 3.
14. „ × ⅜, of *G. Great Barrier Reef 11*; for calicles from the edge, see Pl. III. fig. 6.
15. „ × ½, of *G. North-West Australia 2*; for calicles from surface, see Pl. IV. fig. 1.

PLATE XII.

1. Growth-form, × ½, of *G. Great Barrier Reef 7* (specimen *b*); for calicles from top, see Pl. III. fig. 1.
2. „ × ½, of *G. Great Barrier Reef 10*; for calicles from top, see Pl. III. fig. 5.
3. „ × ½, of *G. North-West Australia 3*; „ „ Pl. IV. fig. 2.
4. „ × ½, of *G. North-West Australia 4*; „ slope, see Pl. IV. fig. 3.
5. „ × ⅓, of specimen *a*, *G. North-West Australia 6*; for calicles from top, see Pl. IV. figs. 5 and 6.
6. „ × ½, of specimen *b*, *G. North-West Australia 6*; for calicles from top, see Pl. IV. fig. 4.
7. „ × ⅓, of *G. Celebes 1*; for normal calicles, see Pl. IV. fig. 8; for abnormal, Pl. IX. fig. 3.
8. „ × ½, of *G. China Sea 2*; for normal calicles, Pl. V. fig. 4.

9*a* and *b*. Two aspects, × ⅝, of *G. China Sea 3*; for normal calicles, see Pl. V. fig. 5.

10. Growth-form, × ⅓, of *G. China Sea 4*; for calicles from top surface, see Pl. V. fig. 6.
11. „ × ½, of *G. China Sea 5*; for magnified tip of right hand fig., see Pl. V. fig. 7; for calicles from lower edge of left fig., see Pl. V. fig. 8.
12. „ × ¼, of *G. Singapore 1*; for calicles of side of a branchlet, see Pl. V. fig. 9.
13. „ × ⅓, of *G. Singapore 2*; for lateral calicles near the tip, see Pl. VI. fig. 1; for lateral calicles lower down, see Pl. VI. fig. 2.

PLATE XIII.

1. Growth-form, × ⅓, of *G. Singapore 3*; { for calicles from the top, see Pl. VI. fig. 3. „ „ side, see Pl. VI. fig. 4.
2. „ × ½, of *G. Singapore 4* (in Brit. Mus.); calicles from specimen in Cambridge Museum, from top, Pl. VI. fig. 5; from side, Pl. VI. fig. 6.
3. „ × ½, of *G. Singapore 5*; calicles from top, Pl. VI. fig. 7; from side, Pl. VI. fig. 8.
4. „ × ⅓, of *G. Singapore 6*; for the type of the calicles, see Pl. VII. fig. 6 and Pl. VIII. fig. 4.
5. „ × ¼, of *G. Ceylon 1*; for calicles, see Pl. VI. fig. 9.

PLATE XIII.—*continued.*

FIG.

6. Growth-form, × ⅓, of *G. Maldives 1*; for calicles, see Pl. VII. fig. 1.
7. „ × ⅓, of *G. Maldives 2*; for top calicles, see Pl. VII. fig. 2; lateral low down, Pl. VII. fig. 3.
8. „ × ⅓, of *G. Maldives 3*; for top calicles, see Pl. VII. fig. 4; lateral, Pl. VII. fig. 5.
9. „ × ⅓, of *G. Maldives 4*; for calicles at the side, see Pl. VII. fig. 6.
10. „ × ¼, of *G. Mauritius 1*; for calicles from tip of a column, see Pl. VII. fig. 7; from explanate surface, see Pl. VII. fig. 8.
11. „ × ½, of *G. Red Sea 4*; for calicles from top surface, see Pl. VII. fig. 9.
12. „ × ⅓, of *G. Red Sea 1*; for calicles from top, see Pl. VIII. fig. 1; from side, Pl. VIII. fig. 2; for illustrations of other growth-forms of same, see Table I.
13. „ × ½, of *G. Red Sea 6*; for (?) worn calicles, see Pl. VIII. fig. 3.

PLATE XIV.

1. Side view of worn pebble, × ½, *Goniopora x b*; for calicles, see Pl. VIII. fig. 8.
2. Growth-form, × ¼, of *Goniopora x c*; for the calicles, see Pl. IX. figs. 1 and 2.
3. „ × ½, of *Goniopora x e*; „ „ Pl. VIII. fig. 7.
4. „ × ½, of *Goniopora x f*; „ „ Pl. VIII. fig. 6.
5. Two calicles, × 10, of specimen *a* of *Goniopora Persia 3*.
6. Growth-form of *Goniopora Vicenza 12*; half natural size.
7. Worn block, × ½, of *Goniopora Gironde 2*; for calicles, see Pl. IX. fig. 6.
8. Fragment, × ½, of *Goniopora Gironde 1*; for calicles from top, see Pl. IX. fig. 5.
9. Worn specimen, × ⅔, of *Goniopora Paris Basin 5*; for calicles, see Pl. X. fig. 5.
10. „ of *Goniopora Paris Basin 6*; for calicles, see Pl. X. fig. 6.
11. Specimen, × ½, of *Goniopora Paris Basin 9*; „ „ Pl. X. fig. 9.
12. Growth-form, × 1, of specimen *a* of *Goniopora Paris Basin 11*; for calicles, see Pl. X^a. fig. 3.
13. „ × 1, of *Goniopora Paris Basin 13*; for calicles, see Pl. X^a. fig. 7.
14. „ of specimen *a* of *Goniopora Paris Basin 14*; for calicles, see Pl. X^a. figs. 5 and 6.
15. Fragment of a Greensand coral closely resembling a *Goniopora*, see Text, p. 153.

15*a*. Diagram to show the type of the calicles of the same, which are too fragmentary to photograph.

16. Growth-form, × ½, of *Goniopora Coutances 1*, specimen *b*; for calicles of specimen *a*, see Pl. X^b. fig. 1.
17. Two calicles, × 5, from *Goniopora* (?) *Antigua 1*.

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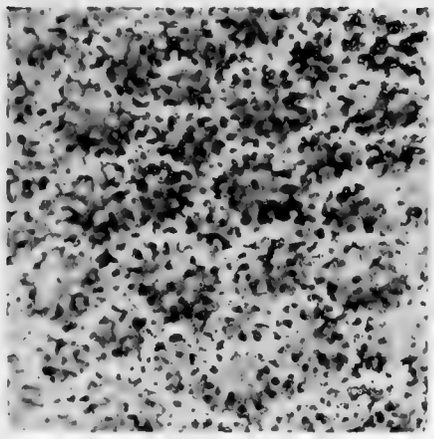

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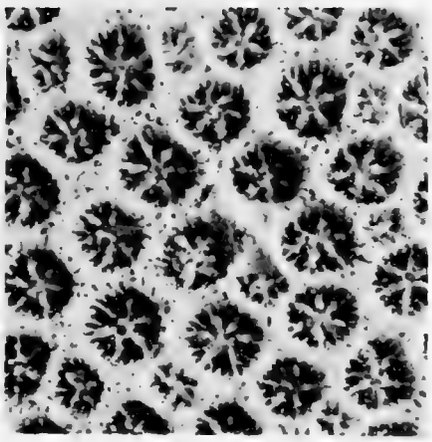

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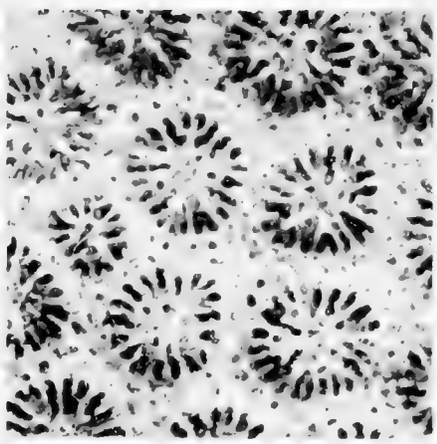

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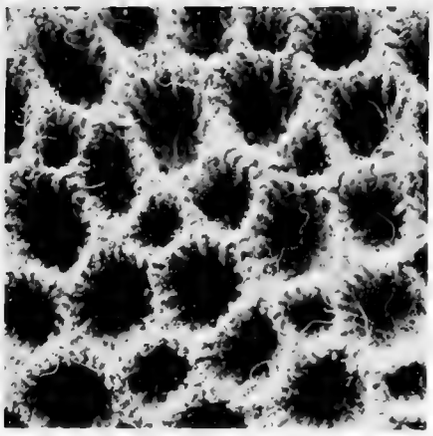

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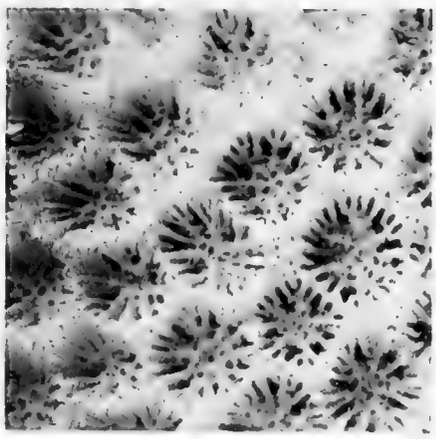

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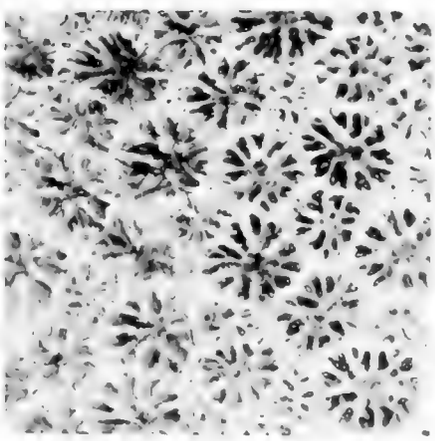

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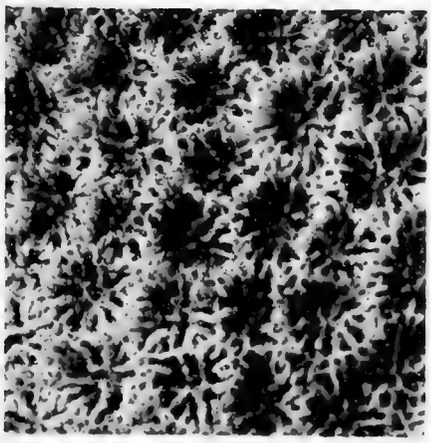

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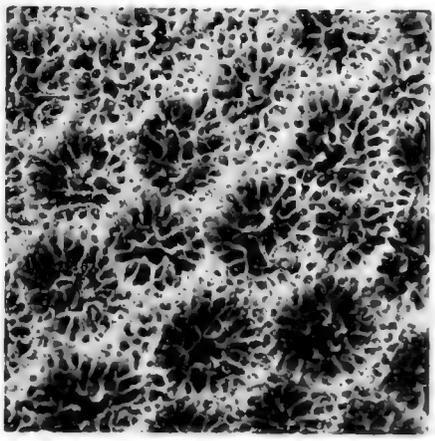

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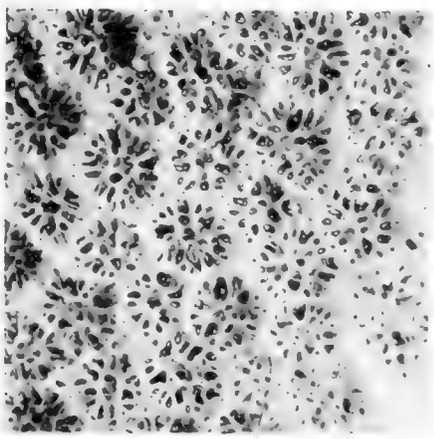

9.

GONIOPORA.

1-3. SOLOMON Is. 4. LOYALTY Is 5-7. TONGA Is. 8-9. SAMOA.

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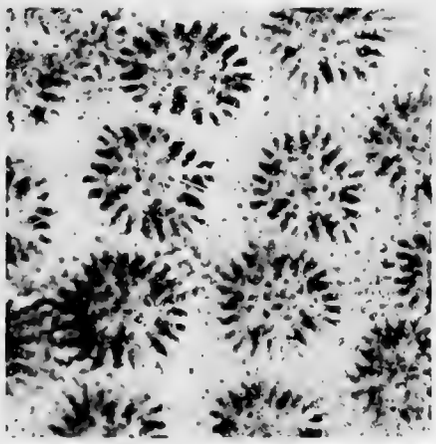

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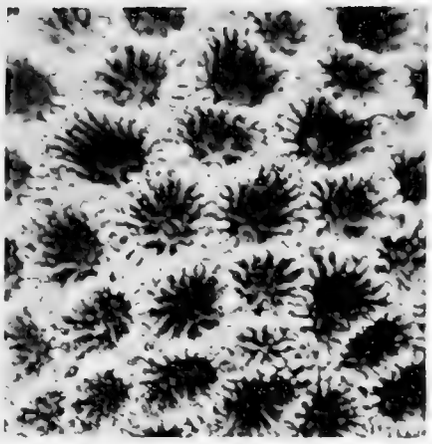

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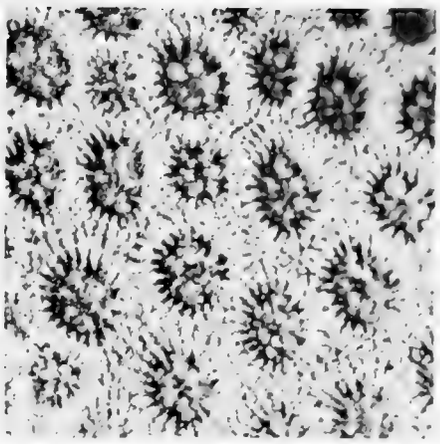

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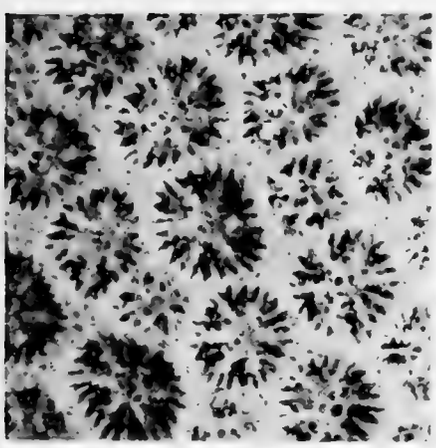

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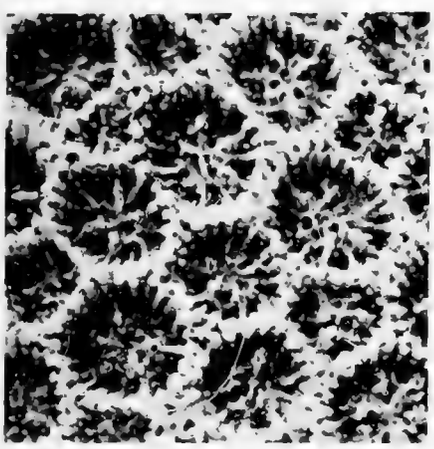

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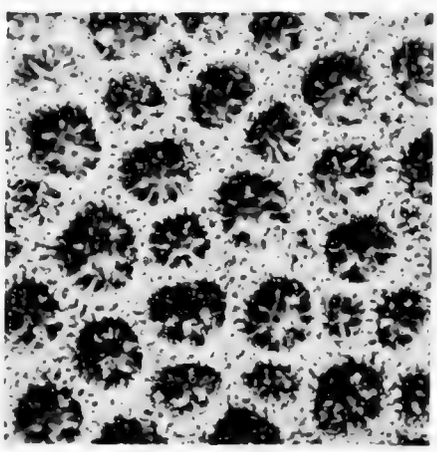

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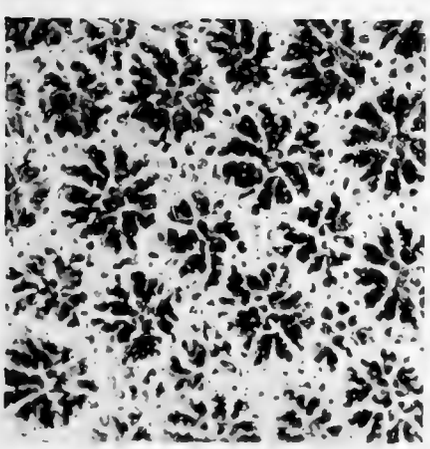

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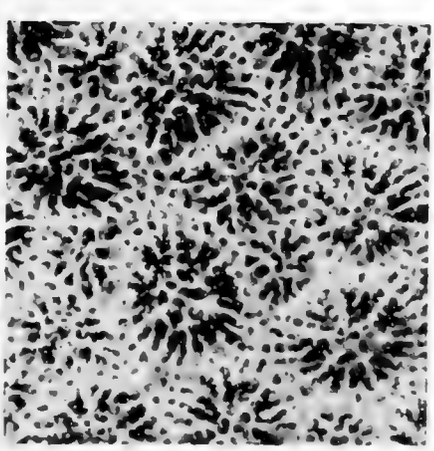

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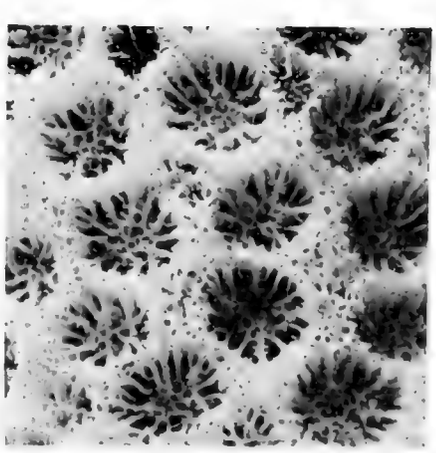
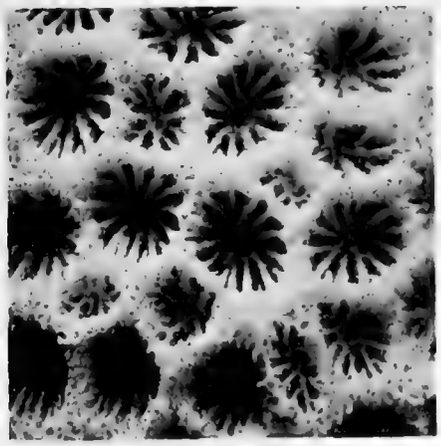


9.

GONIOPORA.

GREAT BARRIER REEF.

Collo: Morgan & Kidd, Richmond, S.W



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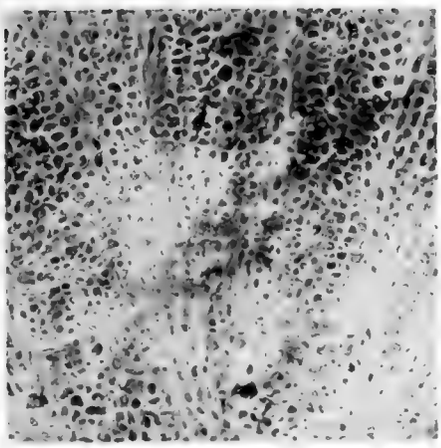

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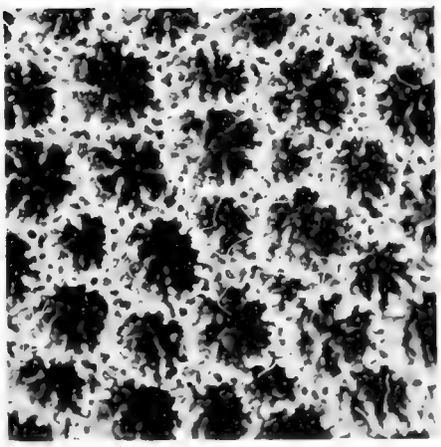

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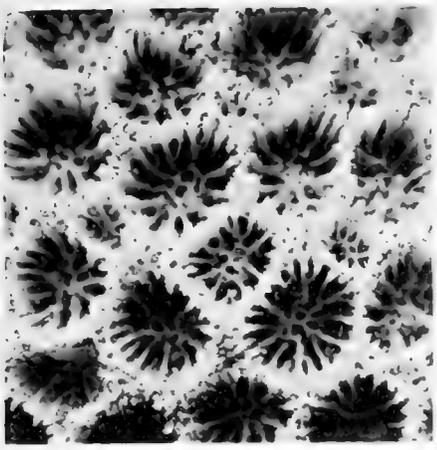

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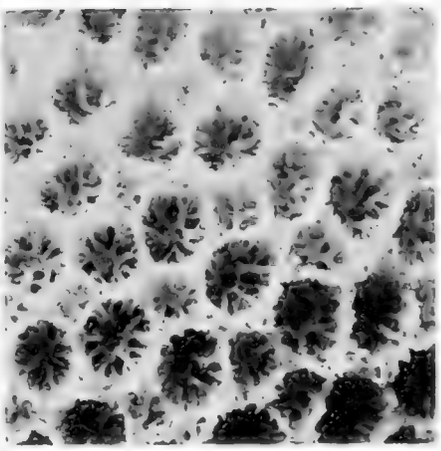

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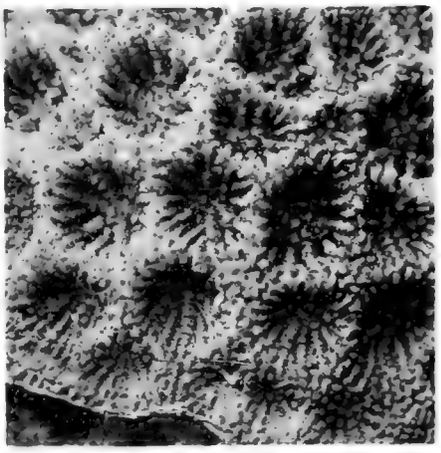

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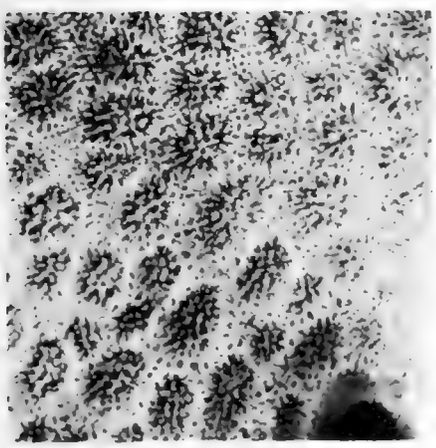

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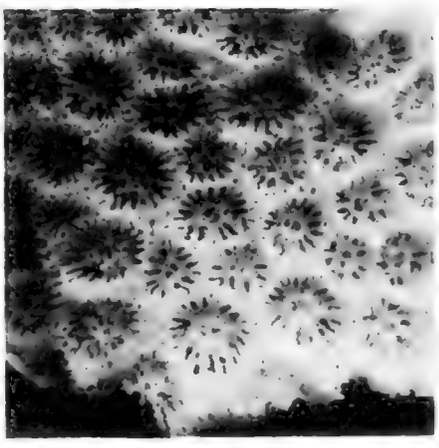

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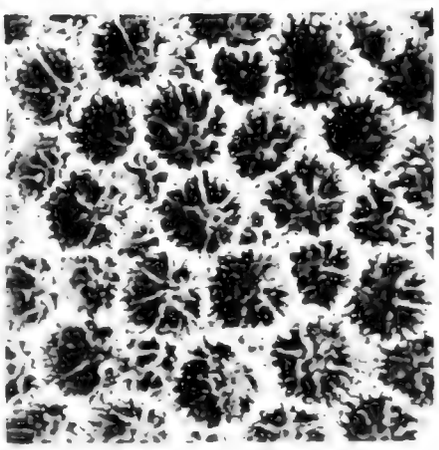

9.

GONIOPORA.

1-8. GREAT BARRIER REEF. 9. N.W. AUSTRALIA.

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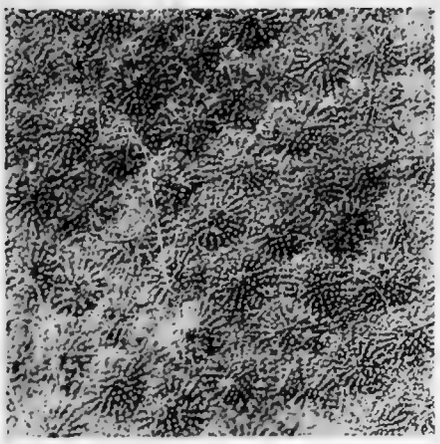

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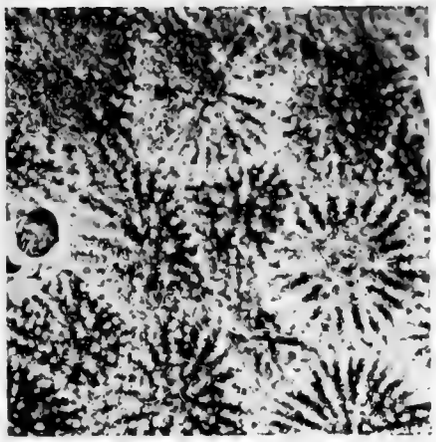

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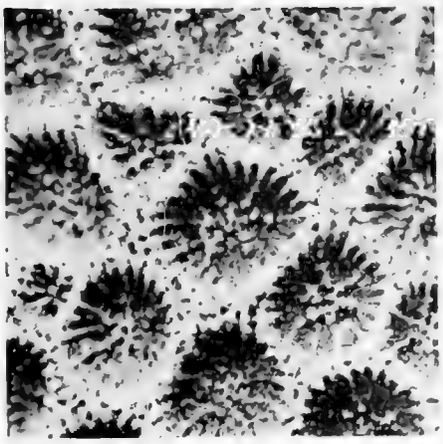

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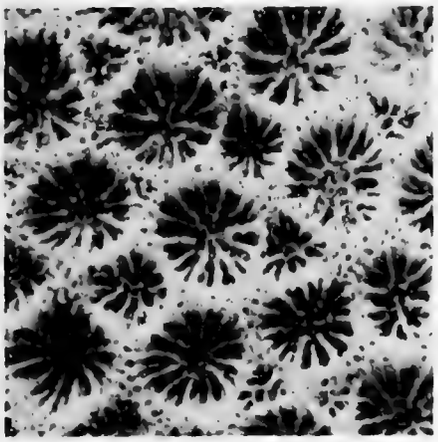

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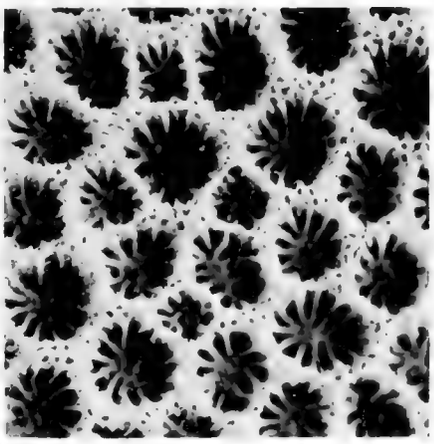

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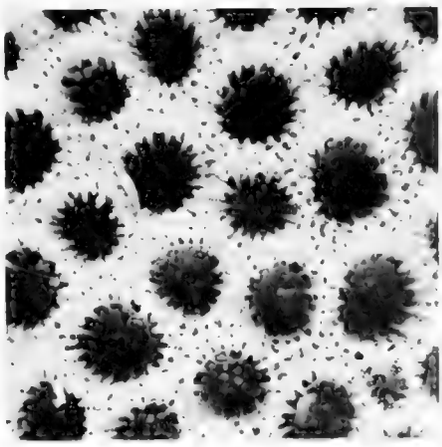

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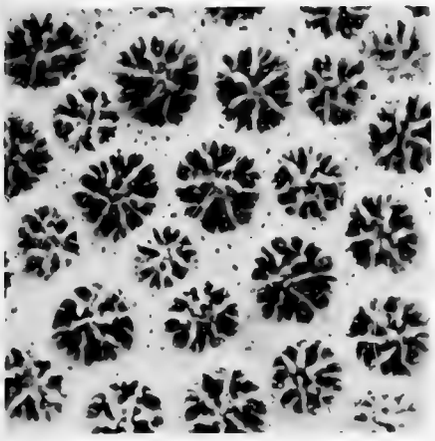

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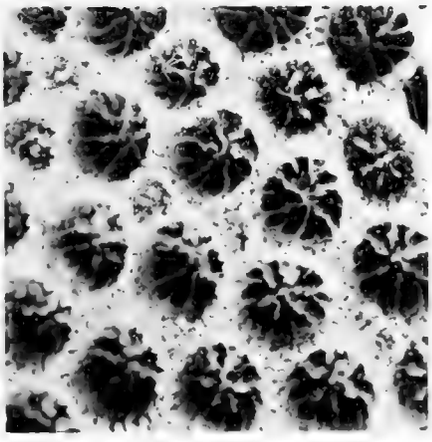

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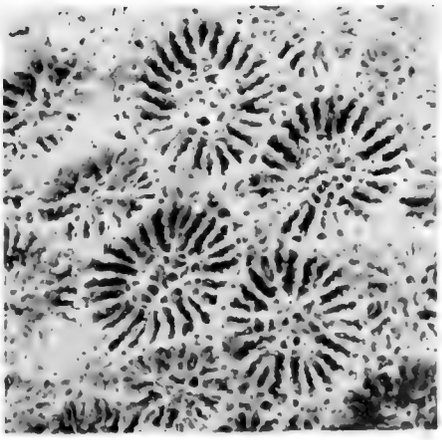

9.

GONIOPORA.

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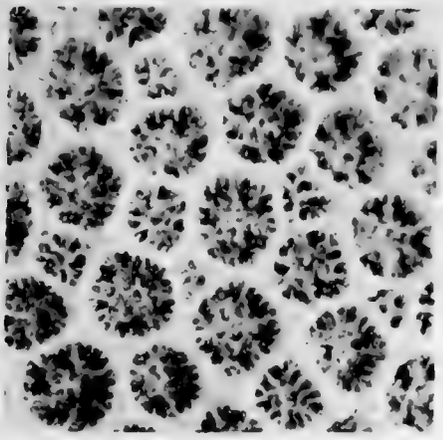
8. CELEBES. 9. PHILIPPINES.

Collo: Morgan & Kidd, Richmond, S.W



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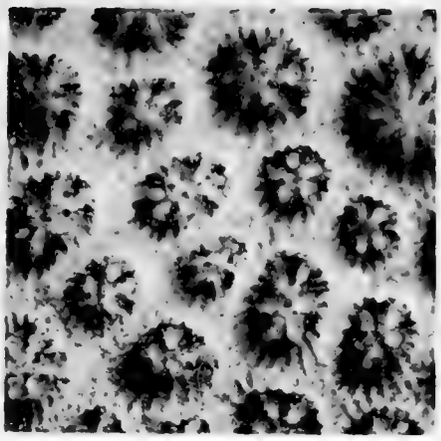

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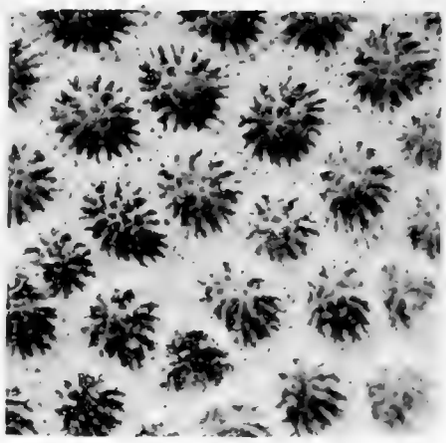

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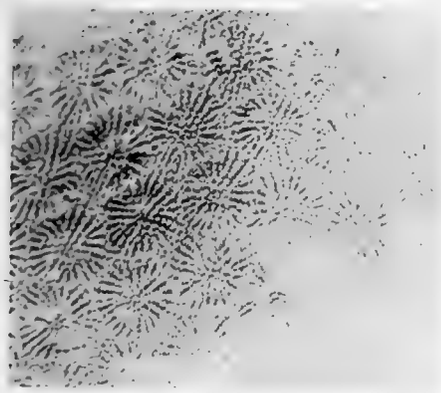

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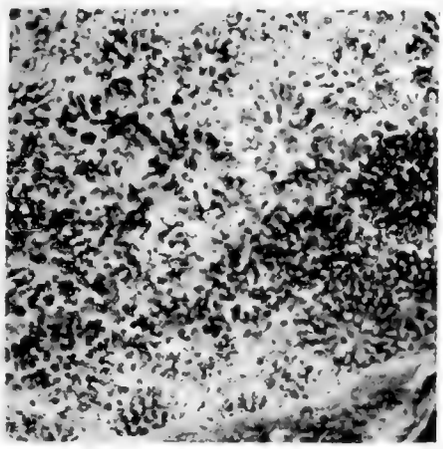

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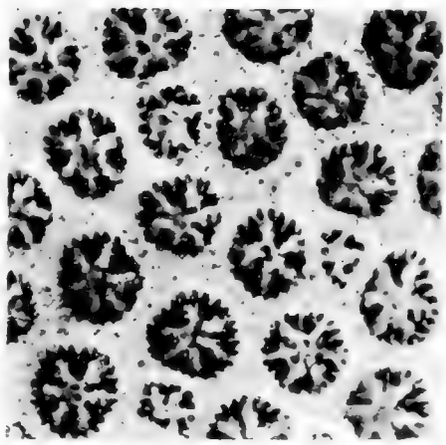

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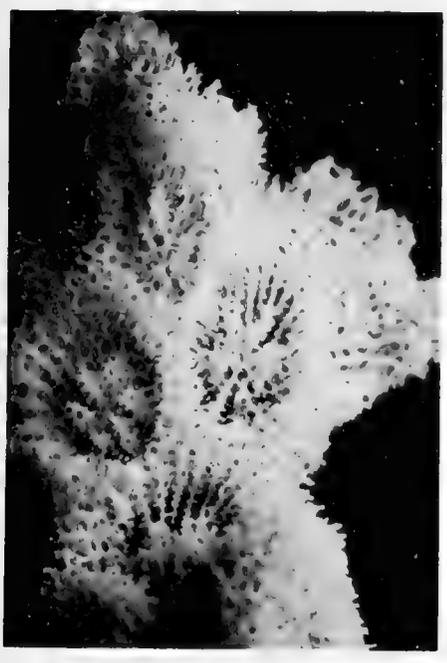

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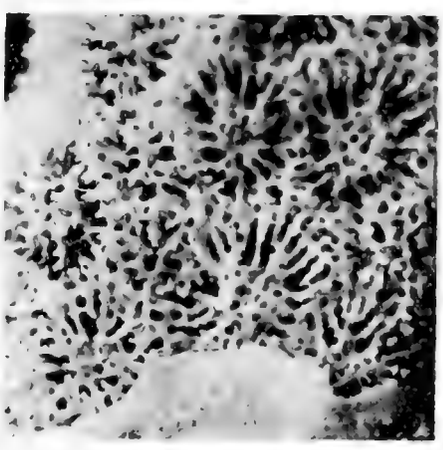

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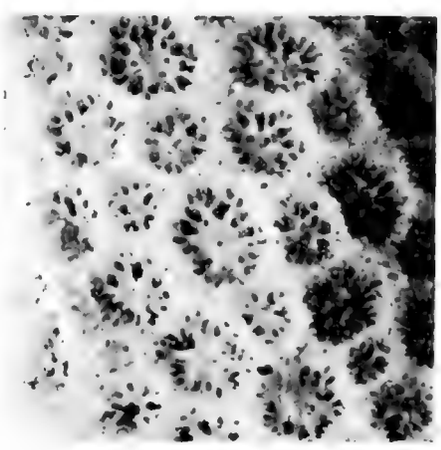
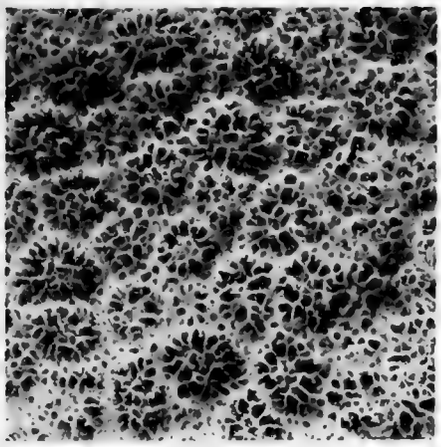


9.

1-3. PHILIPPINES. 4-8. CHINA SEA.

9. SINGAPORE.

Collo: Morgan & Kidd, Richmond, S.W.



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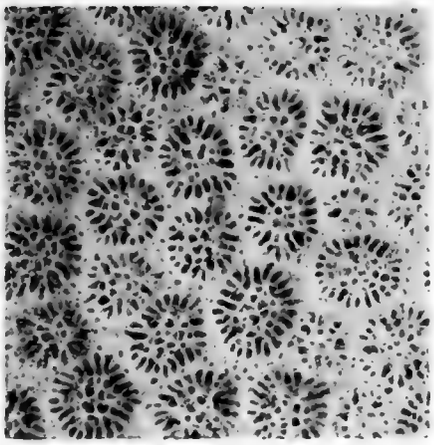

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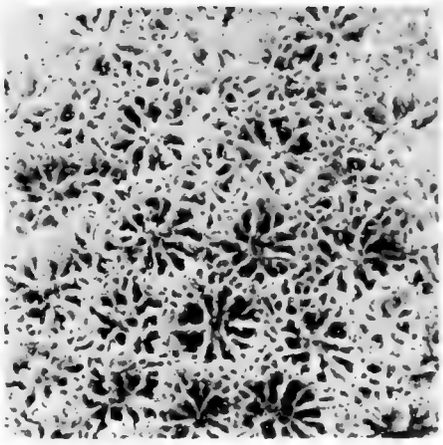

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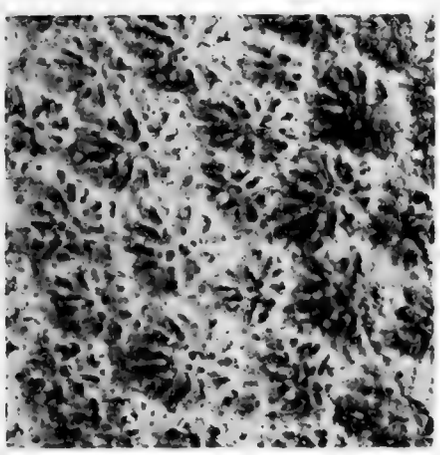

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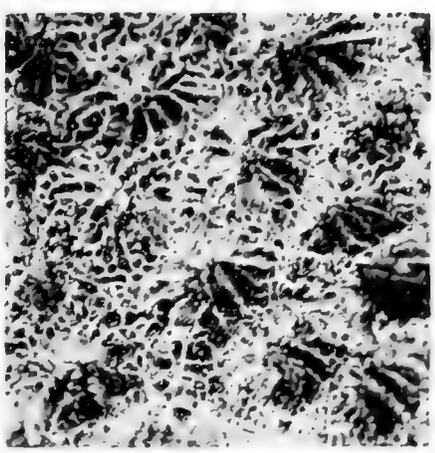

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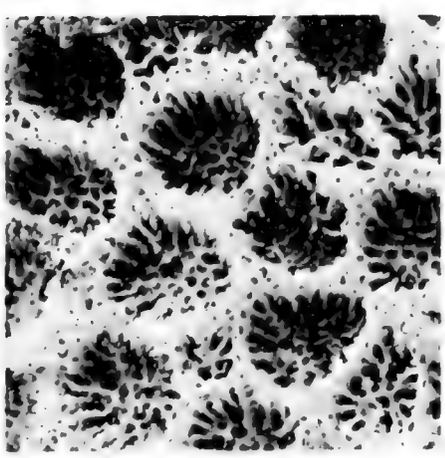

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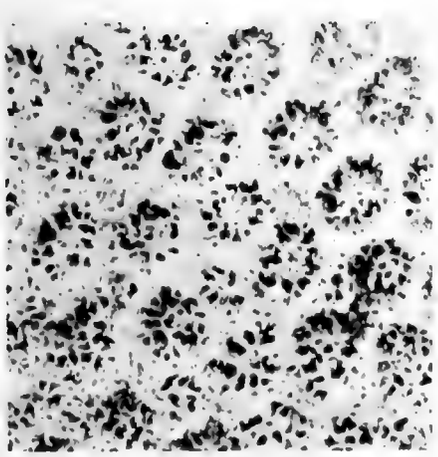

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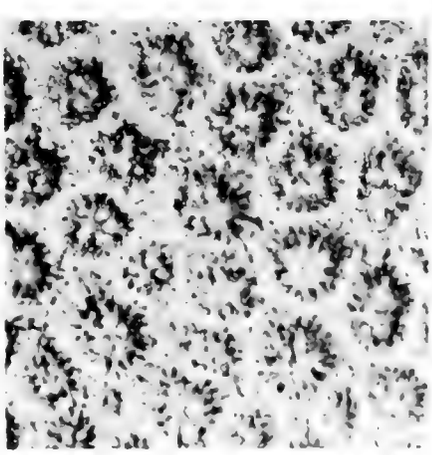

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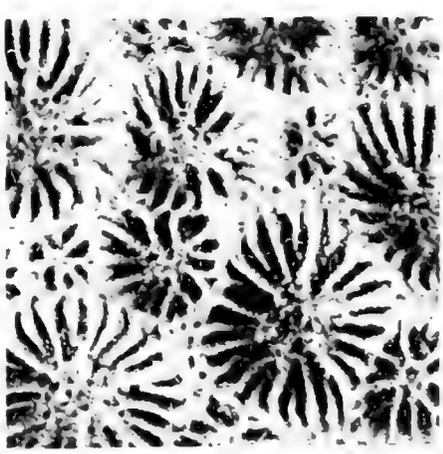
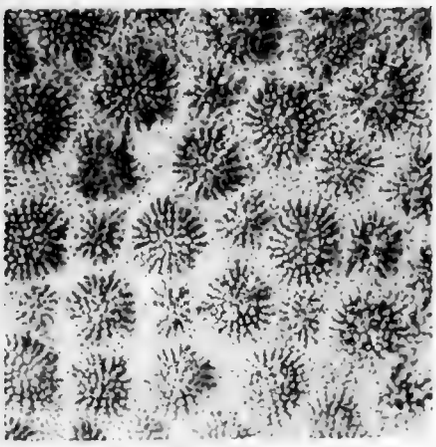


9.

GONIOPORA.

1-8. SINGAPORE. 9. CEYLON.

Collo: Morgan & Kidd, Richmond, S.W.



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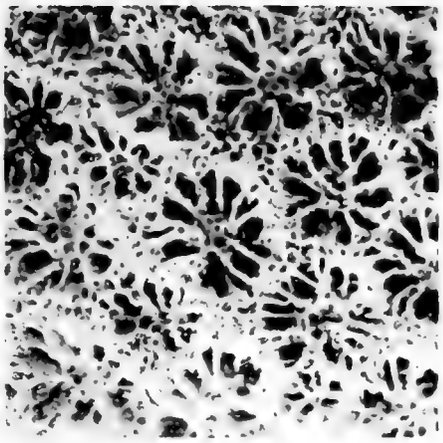

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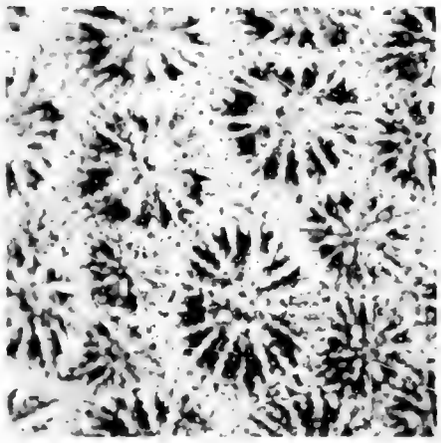

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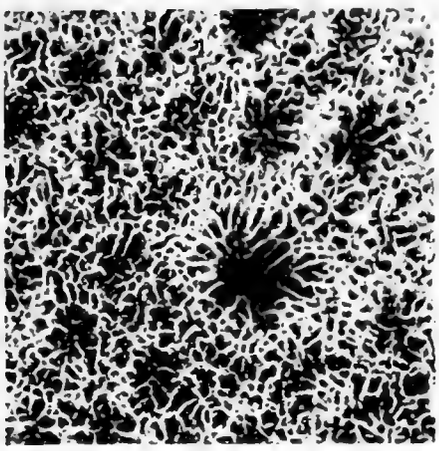

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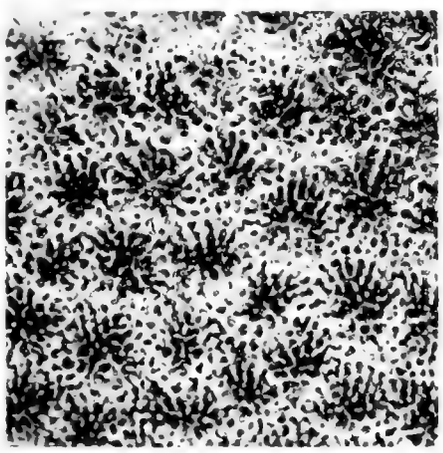

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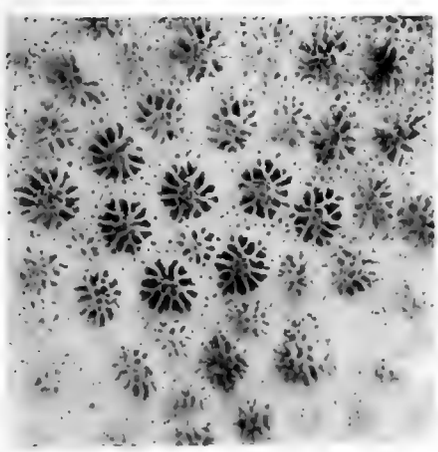

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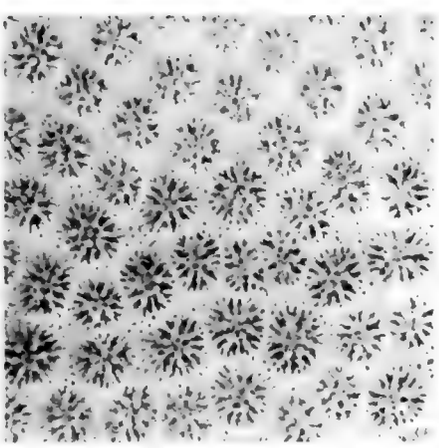

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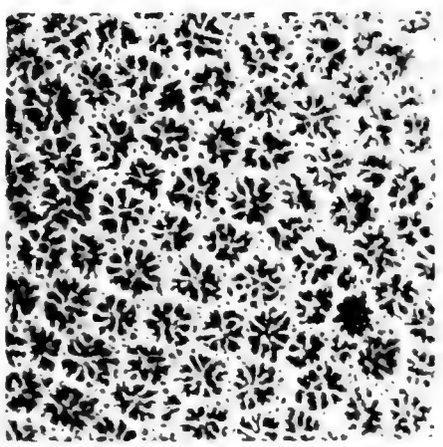


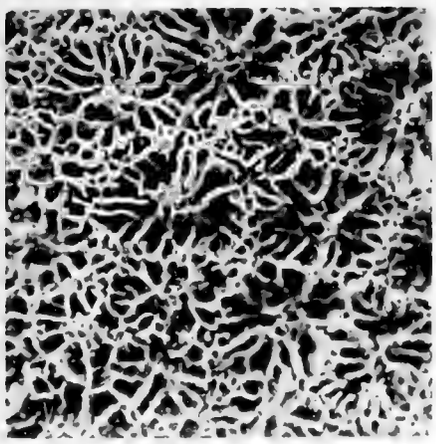
9.

GONIOPORA.

1-6. MALDIVES. 7-8. MAURITIUS.

9. RED SEA.

Collo: Morgan & Kidd, Richmond, S.W.



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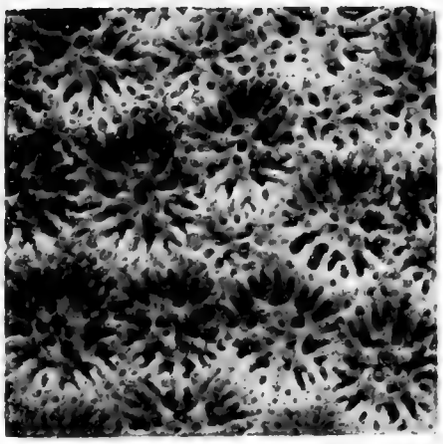

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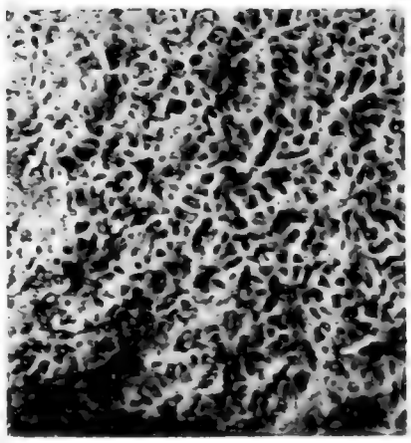

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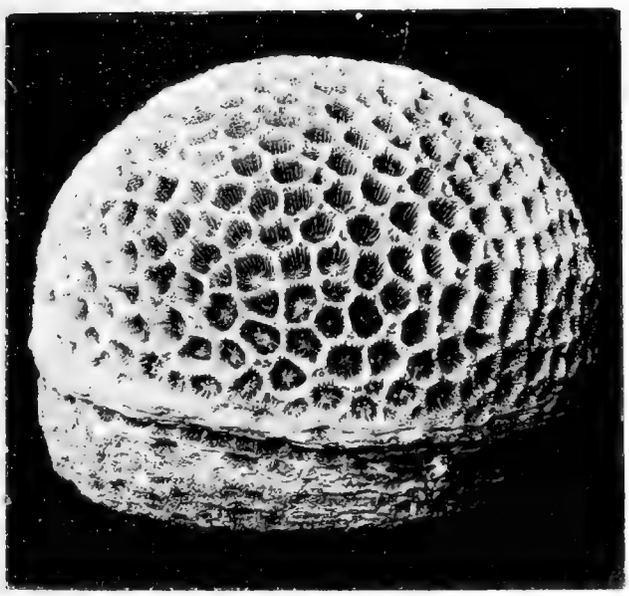

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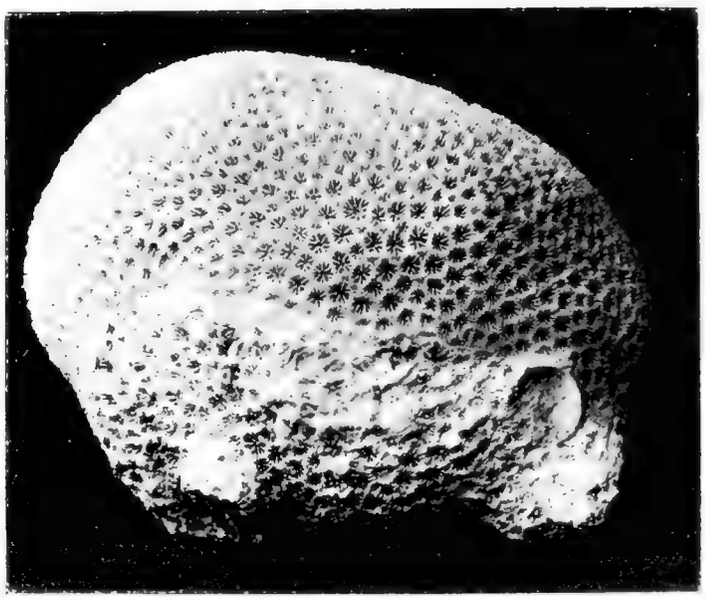

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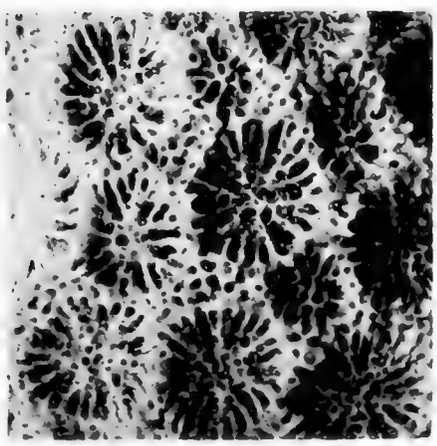

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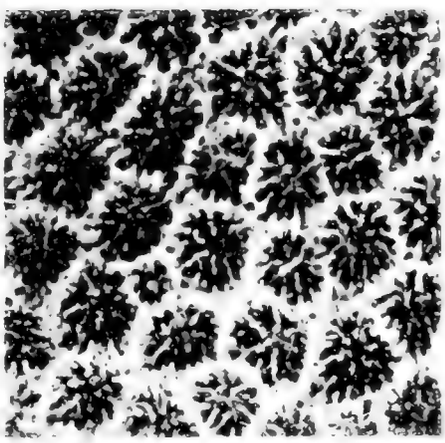

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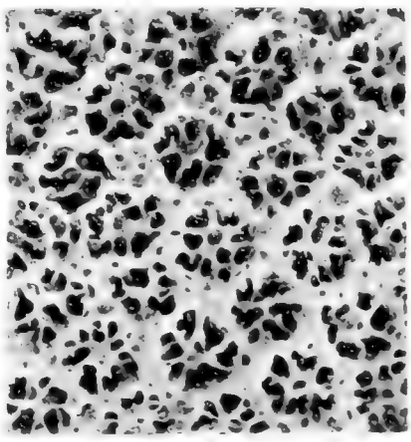
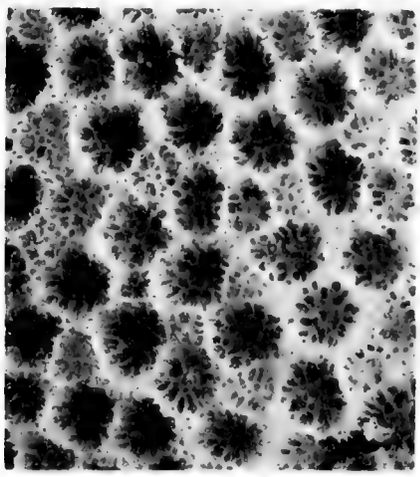


8.

GONIOPORA.

1-3. RED SEA. 4-8. LOCALITIES UNKNOWN.

Collo: Morgan & Kidd, Richmond, S.W.



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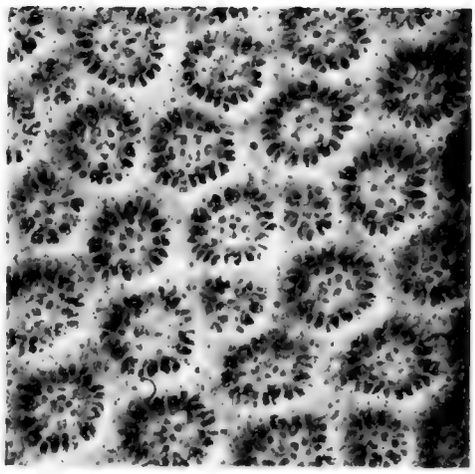

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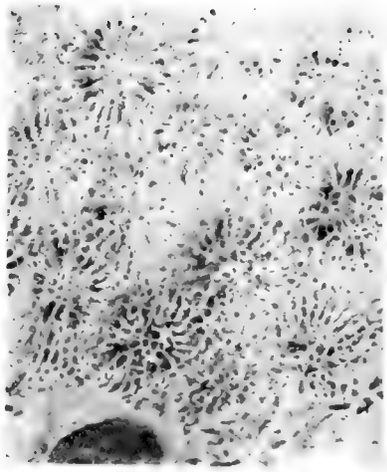

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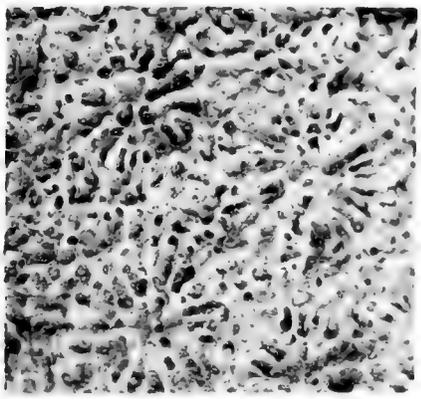

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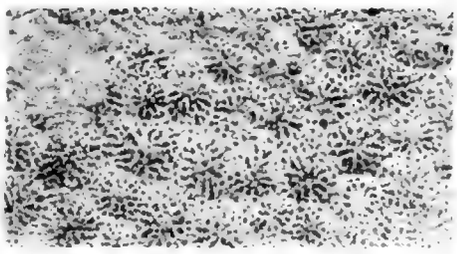

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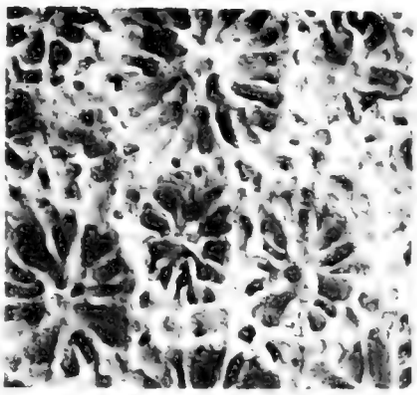

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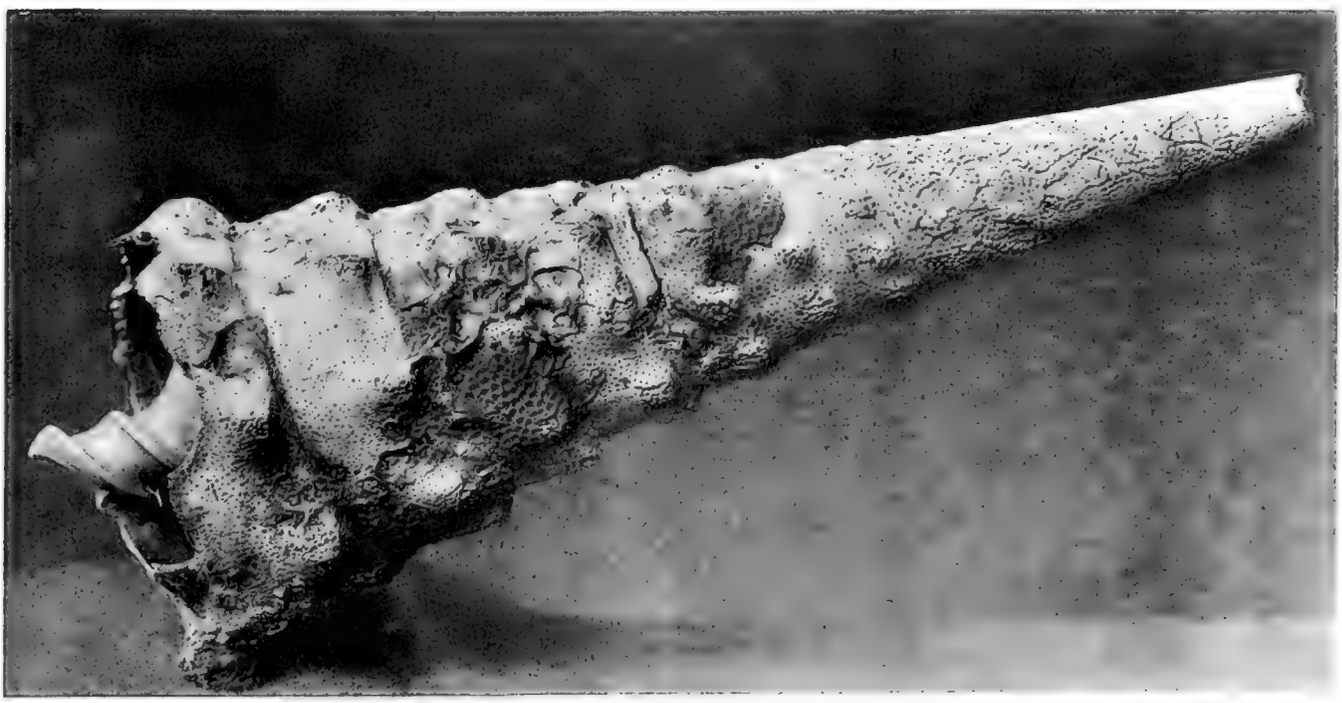
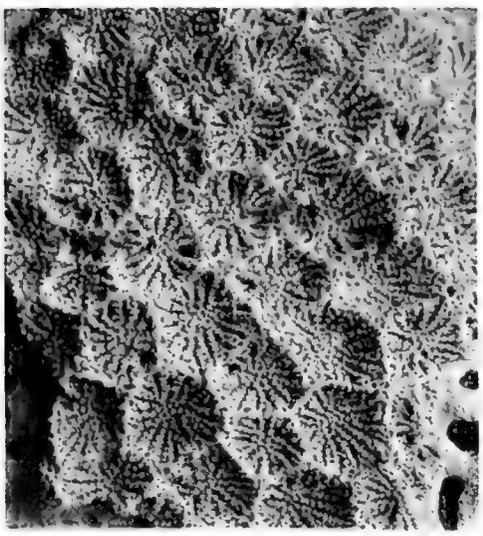


7

1-3 RECENT. 4-7 FOSSIL.

GONIOPORÆ.



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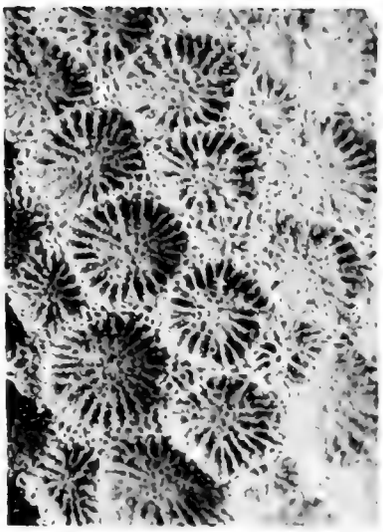

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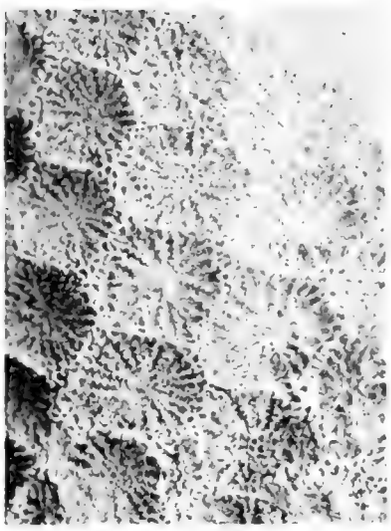

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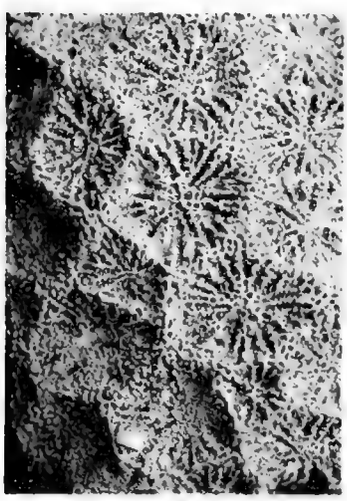

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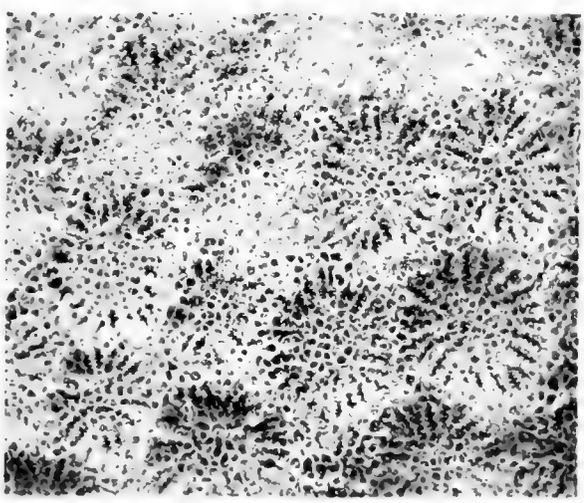

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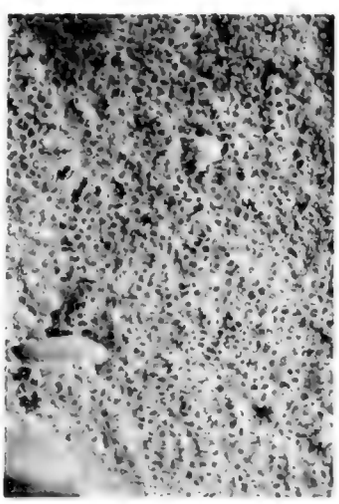

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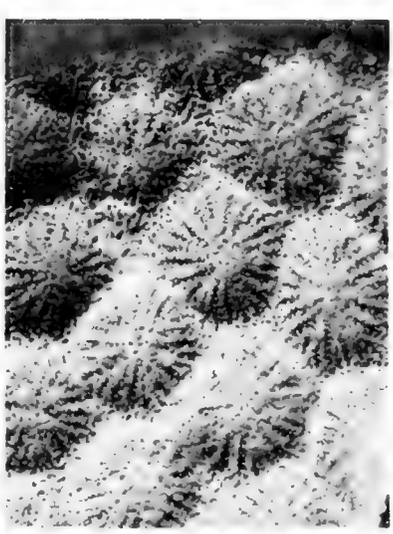

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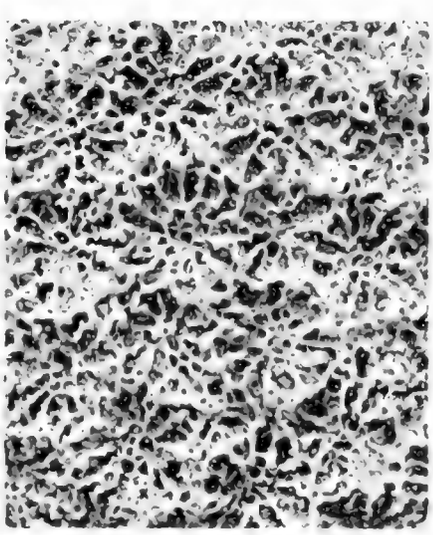
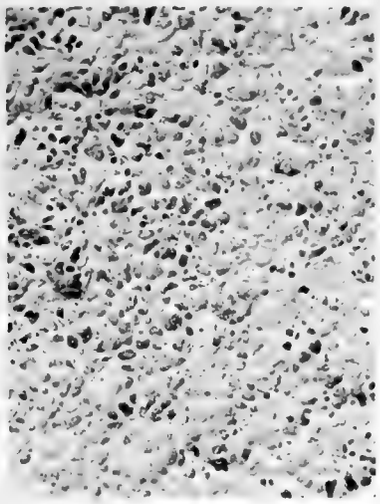


9

FOSSIL GONIOPORÆ.



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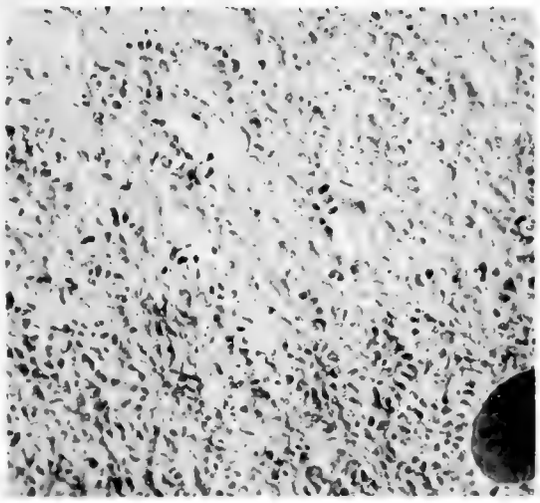

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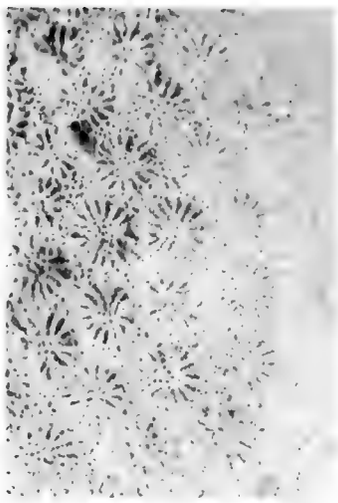

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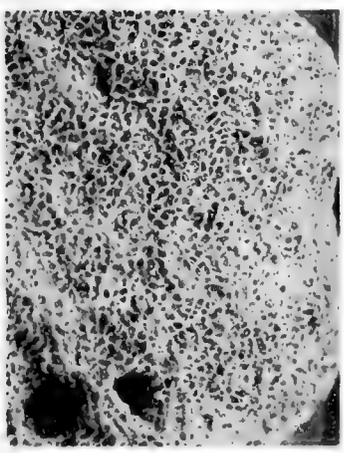

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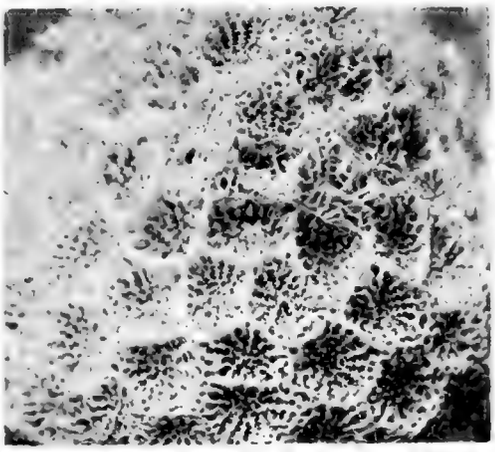

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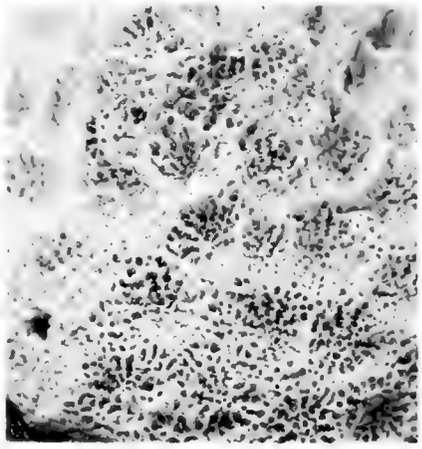

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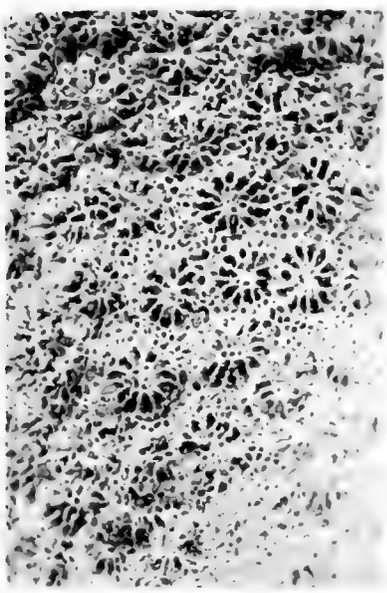

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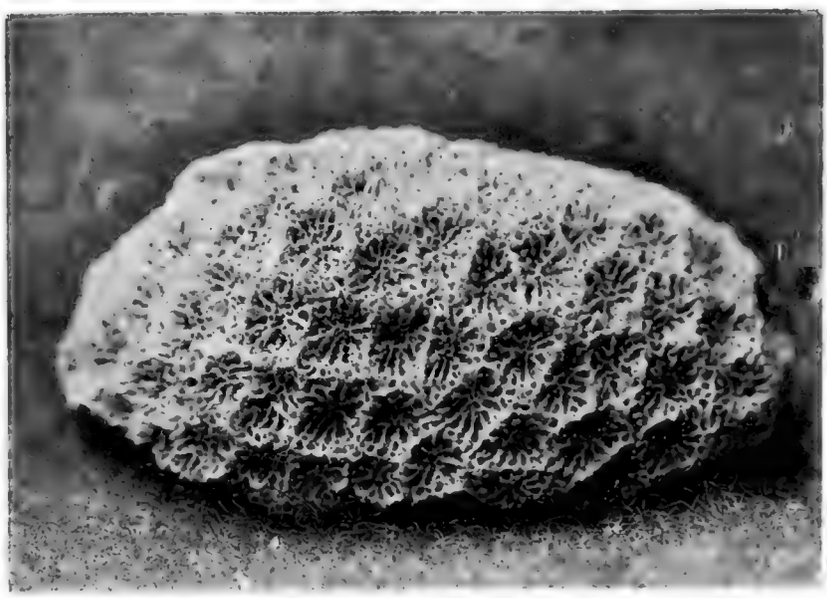

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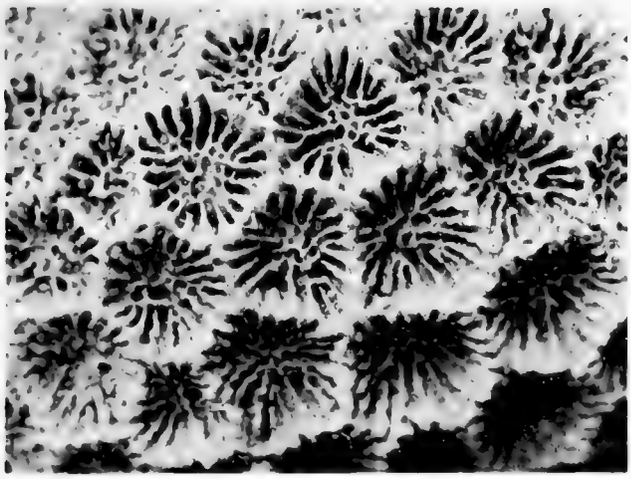
FOSSIL GONIOPORÆ.



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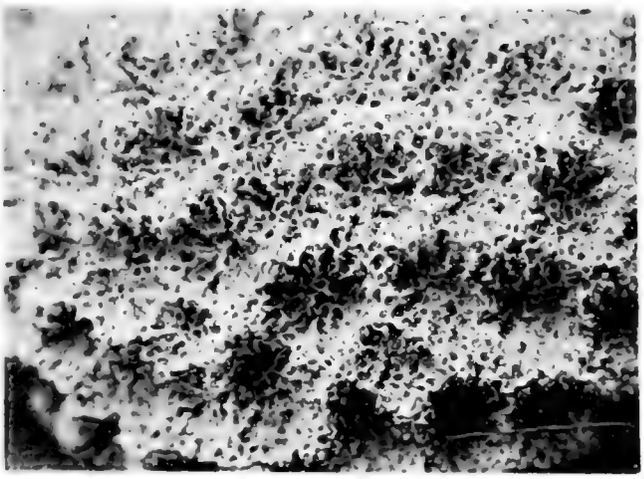

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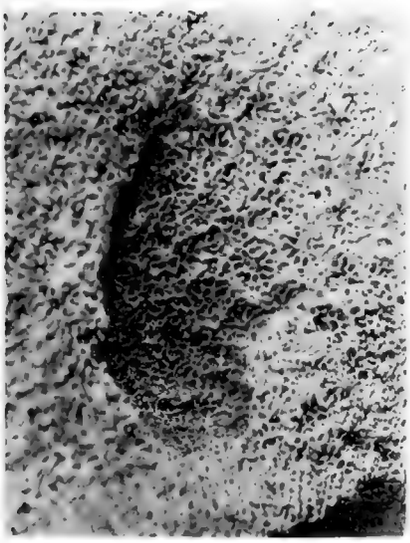

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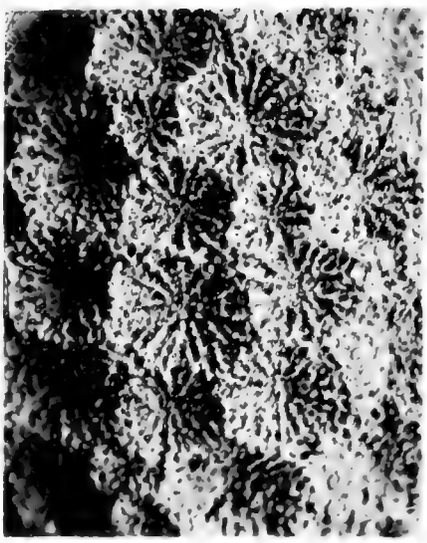

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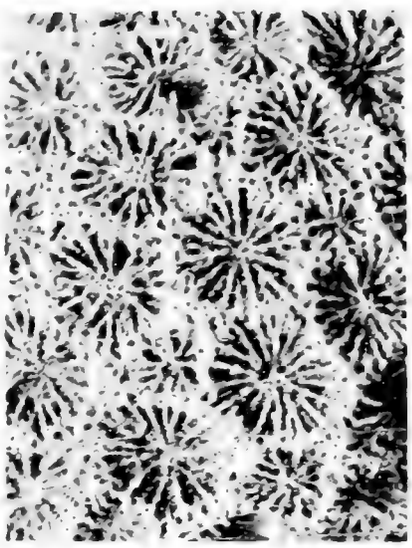

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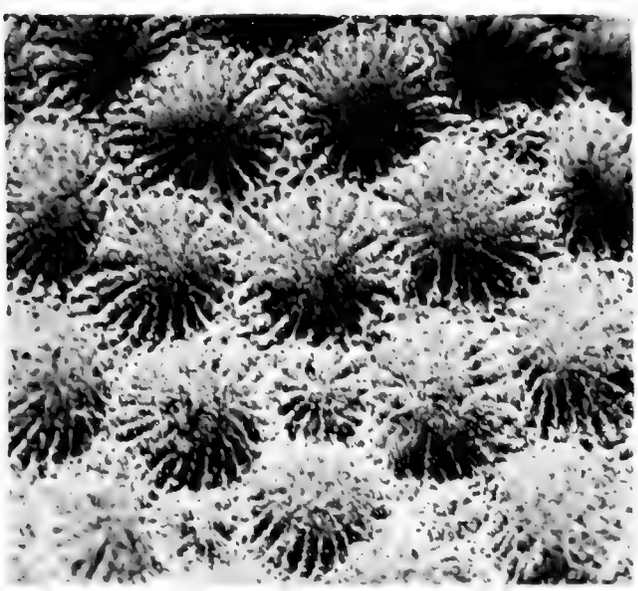

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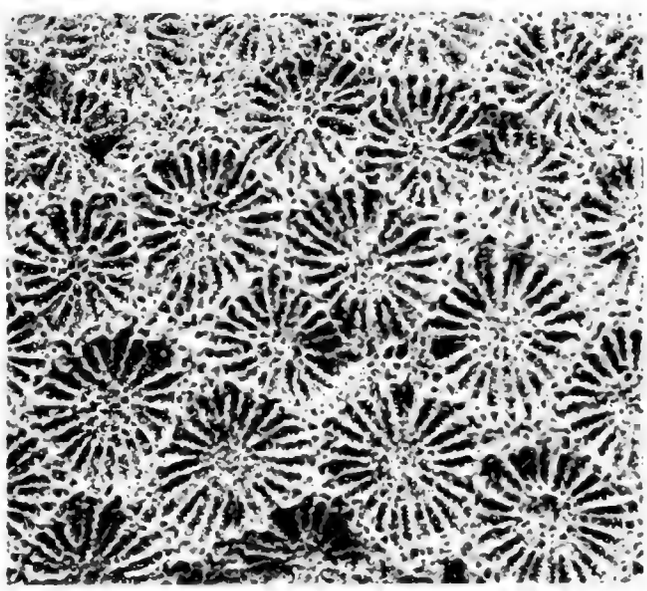

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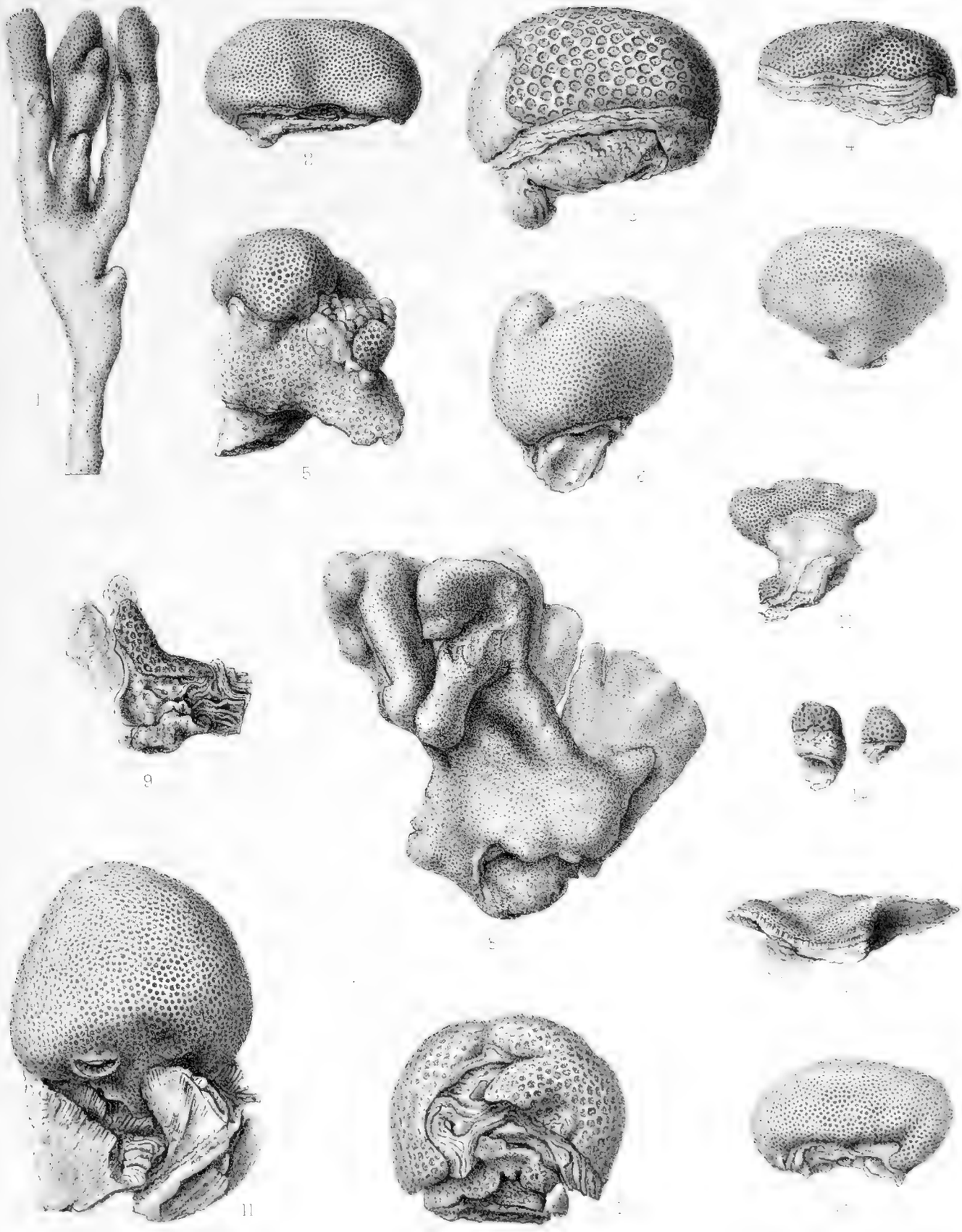
FOSSIL GONIOPORÆ.



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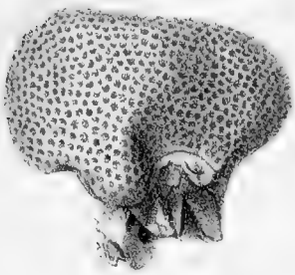
GROWTH-FORMS OF GONIOPORA



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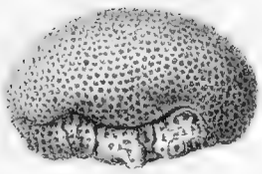

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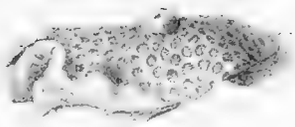

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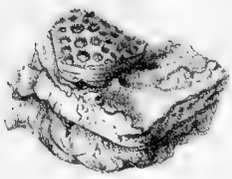

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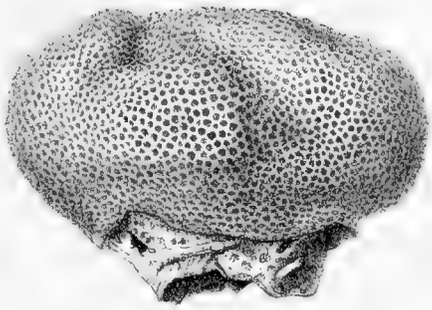

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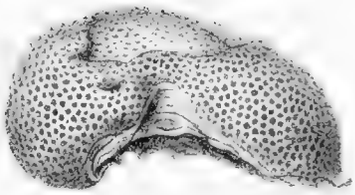

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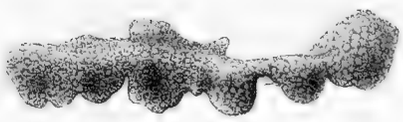

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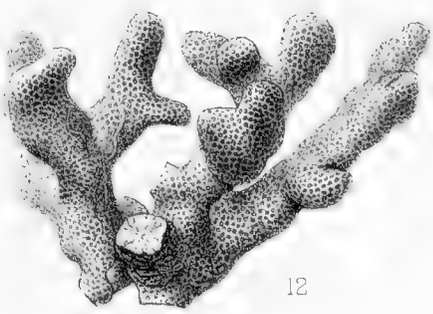

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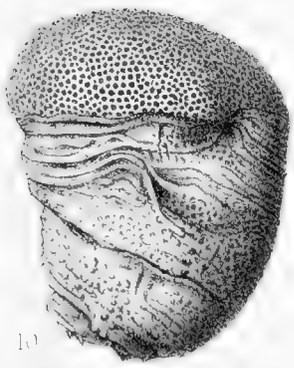

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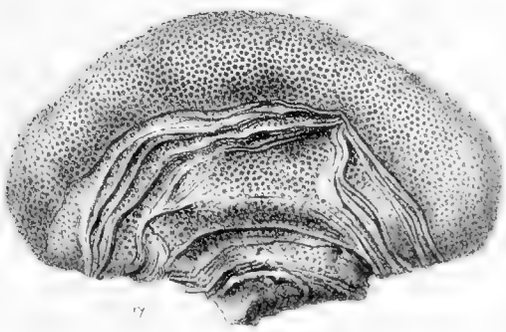

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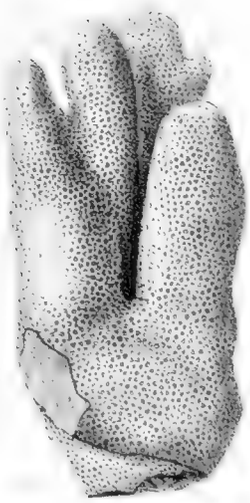

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